Chapter 9

Central Sand Hills Ecological Landscape






Where to Find the Publication

The Ecological Landscapes of Wisconsin publication is available online, in CD format, and in limited quantities as a hard copy. Individual chapters are available for download in PDF format through the Wisconsin DNR website (http://dnr.wi.gov/, keyword "landscapes"). The introductory chapters (Part 1) and supporting materials (Part 3) should be downloaded along with individual ecological landscape chapters in Part 2 to aid in understanding and using the ecological landscape chapters. In addition to containing the full chapter of each ecological landscape, the website highlights key information such as the ecological landscape at a glance, Species of Greatest Conservation Need, natural community management opportunities, general management opportunities, and ecological landscape and Landtype Association maps (Appendix K of each ecological landscape chapter). These web pages are meant to be dynamic and were designed to work in close association with materials from the Wisconsin Wildlife Action Plan as well as with information on Wisconsin's natural communities from the Wisconsin Natural Heritage Inventory Program.

If you have a need for a CD or paper copy of this book, you may request one from Dreux Watermolen, Wisconsin Department of Natural Resources, P.O. Box 7921, Madison, WI 53707.

Photos (L to R): Karner blue butterfly, photo by Gregor Schuurman, Wisconsin DNR; small white lady's-slipper, photo by Drew Feldkirchner, Wisconsin DNR; ornate box turtle, photo by Rori Paloski, Wisconsin DNR; Fassett's locoweed, photo by Thomas Meyer, Wisconsin DNR; spatterdock darner, photo by David Marvin.

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Cover Photos

Top left: *Some parts of the Central Sand Hills feature mixtures of "southern" and "northern" plants. This forest is dominated by large black oak and eastern white pine. Photo by Josh Meyer.*

Center left: *Slender glass lizard (Wisconsin Endangered) inhabits sandy oak savannas and open woodlands. Photo by A.B. Sheldon.*

Bottom left: *Extensive Northern Sedge Meadow dominated by wire-leaved sedges. Numerous rare species have been documented here. Comstock Bog-Meadow State Natural Area, Marquette County. Photo by Eric Epstein, Wisconsin DNR.*

Top right: *Calcareous fen, oak forest, and spring-fed drainage lake. Muir Park State Natural Area, Marquette County. Photo by Wisconsin DNR staff.*

Center right: *Wedde Creek Savanna features large open-grown oaks over a diverse understory of prairie plants. Photo by Josh Meyer.*

Bottom right: *Fassett's locoweed is a Wisconsin endemic. It grows on the sandy shores of seepage lakes that experience dramatic annual water level fluctuations. Photo by Joel Trick, U.S. Fish and Wildlife Service.*

Wisconsin DNR staff

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Size

The Central Sand Hills Ecological Landscape encompasses 2,170 square miles (1,388,705 acres), representing 3.9% of the area of the state of Wisconsin.

Climate

Typical of south central Wisconsin, the Central Sand Hills has a mean growing season of 144 days, mean annual temperature of 44.8°F, average January minimum temperature of 4°F, average August maximum temperature of 81°F, mean annual precipitation of 33 inches, and mean annual snowfall of 44 inches. Although the climate is suitable for agricultural row crops, small grains, and pastures, the sandy soils somewhat limit agricultural potential.

Bedrock

Bedrock exposures are limited but include Precambrian rhyolite bluffs, and a vertical exposure of Ordovician St. Peter sandstone with a thin dolomite cap at Gibraltar Rock in Columbia County.

Geology and Landforms

The landforms in this ecological landscape include a series of glacial moraines: the Johnstown Moraine is the terminal moraine of the Green Bay Lobe; the Arnott Moraine is older and has more subdued topography. Pitted outwash is extensive in some areas. Glacial tunnel channels occur here, e.g., in Waushara County, just east of and visible from I-39.

Soils

Soils are primarily sands. Organic soils underlie wetlands such as tamarack swamps and sedge meadows. Muck farming (on drained peatlands) still occurs in some areas.

Hydrology

There is a mosaic of extensive wetlands and small kettle lakes in the outwash areas, and the headwaters of coldwater streams originating in glacial moraines. Some seepage lakes and ponds exhibit dramatic natural water level fluctuations that create important Inland Beach and Coastal Plain Marsh habitats. The Wisconsin River and a short but ecologically important stretch of the lower Baraboo River flow through this ecological landscape. Other important rivers include the Fox, Grand, Mecan, Montello, Puchyan, and White. Large impoundments occur on the Wisconsin (Lake Wisconsin), Fox (Buffalo Lake and Lake Puckaway), and Grand (Grand River Marsh) rivers.

Current Land Cover

Land cover is more than one-third agricultural crops, one third forest, and almost 20% grasslands, with smaller amounts of open wetland, open water, shrubs, unvegetated (termed "barren" in WISCLAND), and urban areas. Large contiguous areas of major natural or surrogate vegetation types are uncommon; the prevalent land cover pattern is of small to medium-sized patches in mosaics of natural, agricultural, and residential lands.

Socioeconomic Conditions

The counties included in this socioeconomic region are Portage, Waushara, Marquette, Green Lake, and Columbia.

Population

The population was 185,803 in 2010, or 3.3% of the state total.

Population Density

62 persons per square mile

Per Capita Income

$30,777

Important Economic Sectors

The largest employment sectors in 2007 were Government (13.2% versus 12.1% statewide), Tourism-related (12.6% versus 11.2%), Manufacturing (non-wood) (12.0% versus 11.7%), and Health Care and Social Services (9.4% versus 10.7%).

Public Ownership

Scattered Federal Waterfowl Production Areas, Fox River National Wildlife Refuge, scattered state-owned and managed lands including Hartman Creek State Park, several state wildlife areas, fisheries areas, and natural areas occur here. A map showing public land ownership (county, state, and federal) and private lands enrolled in the forest tax programs can be found in Appendix 9.K.

Other Notable Ownerships

The Nature Conservancy has been active in this ecological landscape, with projects at sites that include Summerton Bog and Page Creek Marsh.

Considerations for Planning and Management

Important concerns and considerations in the Central Sand Hills include the fragmentation and isolation of major habitats, groundwater withdrawals, ground and surface water contamination, hydrologic disruption due to ditching and diking of wetlands, fire suppression and the loss of fire-dependent habitats and species, shoreline development, and the introduction and spread of invasive species. Poor water quality exists in some lakes and impoundments. Ground water contamination is also an issue here. Excessive groundwater withdrawals could have serious negative consequences in areas supporting coldwater streams and seepage lakes and within the recharge areas of groundwater-dependent natural communities such as Coastal Plain Marsh, Calcareous Fen, Tamarack Swamp, and Southern Sedge Meadow. Fire suppression has altered successional pathways that formerly maintained oak forests, savannas, prairies, and other fire-adapted or dependent vegetation.

Management Opportunities

Fire-dependent communities were once common and widespread in the Central Sand Hills. Although today's examples are mostly small remnants, there are excellent opportunities to manage for fire-dependent and fire-adapted communities, such as oak forest, oak woodland, oak savanna, tallgrass prairie, sedge meadow, and fen. Remnant savannas (both Oak Barrens and Oak Openings) occur on dry and dry-mesic sites scattered throughout the Central Sand Hills. All of these communities have high potential to support rare plants, invertebrates, and reptiles.

Dry forests of white, black, and bur oak are common, though forest management at large scales is constrained by ownership patterns and small tract size and current land uses. Management of oak forests and woodlands could be integrated with management of oak savanna, prairie, and wetlands at some sites. This would be especially appropriate on public and private lands managed mostly for conservation purposes. Mixed forests of pine and oak are locally common, and the Central Sand Hills is one of two ecological landscapes where good examples of the Central Sands Pine-Oak Forest community have been documented.

Numerous springs and coldwater streams emanate from the end moraine near the western boundary of the Central Sand Hills. Wetland communities associated with these glacial landforms include fen, sedge meadow, low prairie, shrub swamp, and tamarack swamp; some of these wetlands are alkaline and differ in composition from those found in the more acid environments to the west in the Central Sand Plains Ecological Landscape.

Large wetland complexes, such as those found at Germania Marsh, Comstock Marsh, Grand River Marsh, Fountain Creek Prairie, and Lunch Creek, contain good examples of communities such as fen, sedge meadow, wet prairie, shrub swamp, marsh, and tamarack swamp. The Central Sand Hills Ecological Landscape contains more occurrences of the globally rare Coastal Plain Marsh community than any other landscape in Wisconsin. Coastal Plain Marsh communities provide habitat for rare vascular plants and invertebrates and are associated with sandy or gravelly shores of seepage lakes that exhibit dramatic natural water level fluctuations. The U.S. Threatened/Wisconsin Endangered Fassett's locoweed is strongly associated with Coastal Plain Marsh and Inland Beach communities. Floodplain forest is significant along stretches of major

Extensive Southern Sedge Meadow. Marquette County. Photo by Eric Epstein, Wisconsin DNR.

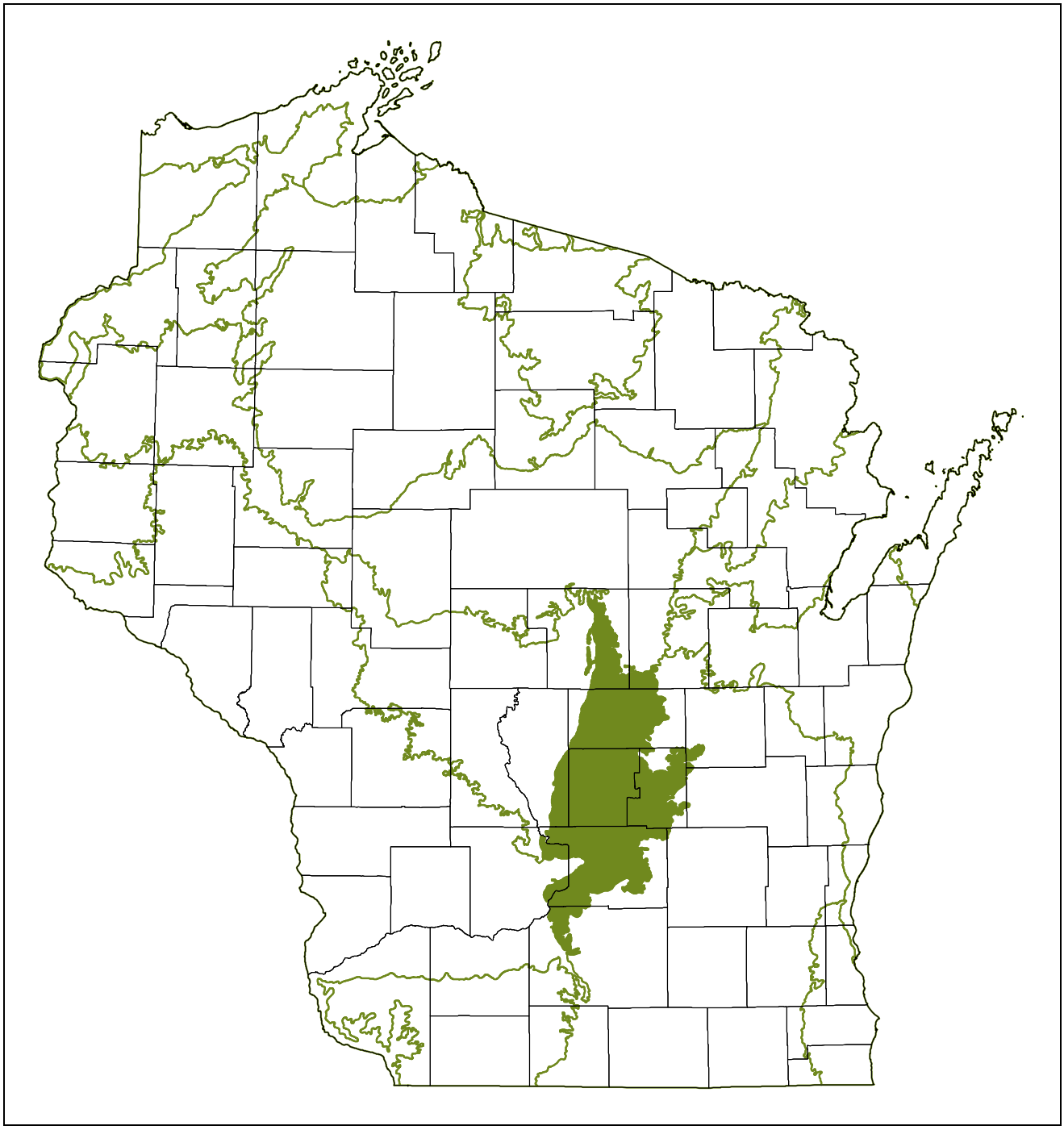
Conifer swamps dominated by tamarack occur in some of the intact peatland complexes in the Central Sand Hills, along with sedge meadow, fen, and shrub swamp communities. Green Lake and Marquette counties. Photo by Andy Clark, Wisconsin DNR.

Dry forests dominated by black and white oaks are common in the Central Sand Hills. Some of them are at least partially the result of fire suppression policies that has led to the replacement of oak savanna by forest. Photo by Andy Clark, Wisconsin DNR.

rivers such as the Wisconsin, Baraboo, and Montello and provides important habitat for rare plants, and resident and migratory wildlife.

Important warmwater rivers include the Fox, Montello, Baraboo, and a short but ecologically significant stretch of the Wisconsin. This section includes Pine Island State Wildlife Area, a site with associated floodplain habitats, as well as significant savanna and grassland remnants. Dams on several of the major rivers have created very large shallow impoundments, including Buffalo Lake, Lake Puckaway, and Lake Wisconsin, and these offer valuable wildlife habitat but need rehabilitation to address their poor water quality. Green Lake, Wisconsin's deepest inland lake, is located in the east central portion of the Central Sand Hills.

Bedrock exposures are rare in the Central Sand Hills. However, they include good examples of glades, cliffs and talus slopes, which support rare plants and other unique vegetation as well as some rare animals.



Central Sand Hills Ecological Landscape

Joel Trick, U.S. Fish & Wildlife Service

Central Sand Hills Ecological Landscape

Introduction

This is one of 23 chapters that make up the Wisconsin DNR's publication *The Ecological Landscapes of Wisconsin: An Assessment of Ecological Resources and a Guide to Planning Sustainable Management*. This book was developed by the Wisconsin DNR's Ecosystem Management Planning Team and identifies the best areas of the state to manage for natural communities, key habitats, aquatic features, native plants, and native animals from an ecological perspective. It also identifies and prioritizes Wisconsin's most ecologically important resources from a global perspective. In addition, the book highlights socioeconomic activities that are compatible with sustaining important ecological features in each of Wisconsin's 16 ecological landscapes.

The book is divided into three parts. Part 1, "Introductory Material," includes seven chapters describing the basic principles of ecosystem and landscape-scale management and how to use them in land and water management planning; statewide assessments of seven major natural community groups in the state; a comparison of the ecological and socioeconomic characteristics among the ecological landscapes; a discussion of the changes and trends in Wisconsin ecosystems over time; identification of major current and emerging issues; and identification of the most significant ecological opportunities and the best places to manage important natural resources in the state. Part 1 also contains a chapter describing the natural communities, aquatic features, and selected habitats of Wisconsin. Part 2, "Ecological Landscape Analyses," of which this chapter is part, provides a detailed assessment of the ecological and socioeconomic conditions for each of the 16 individual ecological landscapes. These chapters identify important considerations when planning management actions in a given ecological landscape and suggest management opportunities that are compatible with the ecology of the ecological landscape. Part 3, "Supporting Materials," includes appendices, a glossary, literature cited, recommended readings, and acknowledgments that apply to the entire book.

This publication is meant as a tool for applying the principles of ecosystem management (see Chapter 1, "Principles of Ecosystem and Landscape-scale Management"). We hope it will help users better understand the ecology of the different regions of the state and help identify management that will sustain all of Wisconsin's species and natural communities while meeting the expectations, needs, and desires of our public and private partners. The book should provide valuable tools for planning at different ***scales***, including master planning for Wisconsin DNR-managed lands, as well as assist in project selection and prioritization.

Many sources of data were used to assess the ecological and socioeconomic conditions within each ecological landscape. Appendix C, "Data Sources Used in the Book" (in Part 3, "Supporting Materials"), describes the methodologies used as well as the relative strengths and limitations of each data source for our analyses. Information is summarized by ecological landscape except for socioeconomic data. Most economic and demographic data are available only on a political unit basis, generally with counties as the smallest unit, so socioeconomic information is presented using county aggregations that approximate ecological landscapes unless specifically noted otherwise.

Rare, declining, or vulnerable species and natural community types are often highlighted in these chapters and are given particular attention when Wisconsin does or could contribute significantly to maintaining their regional or global abundance. These species are often associated with relatively intact natural communities and aquatic features, but they are sometimes associated with cultural features such as old fields, abandoned mines, or dredge spoil islands. Ecological landscapes where these species or community types are either most abundant or where they might be most successfully restored are noted. In some cases, specific sites or properties within an ecological landscape are also identified.

Although rare species are often discussed throughout the book, "keeping common species common" is also an important

Terms highlighted in green are found in the glossary in Part 3 of the book, "Supporting Materials." Naming conventions are described in Part 1 in the Introduction to the book. Data used and limitation of the data can be found in Appendix C, "Data Sources Used in the Book," in Part 3.

consideration for land and water managers, especially when Wisconsin supports a large proportion of a species' regional or global population or if a species is socially important. Our hope is that the book will assist with the regional, statewide, and landscape-level management planning needed to ensure that most, if not all, native species, important habitats, and community types will be sustained over time.

Consideration of different scales is an important part of ecosystem management. The 16 ecological landscape chapters present management opportunities within a context of ecological functions, natural community types, specific habitats, important ecological processes, localized environmental settings, or even specific populations. We encourage managers and planners to include these along with broader landscape-scale considerations to help ensure that all natural community types, ***critical habitats***, and aquatic features, as well as the fauna and flora that use and depend upon them, are sustained collectively across the state, region, and globe. (See Chapter 1, "Principles of Ecosystem and Landscape-scale Management," for more information.)

Locations are important to consider since it is not possible to manage for all species or community types within any given ecological landscape. Some ecological landscapes are better suited to manage for particular community types and groups of species than others or may afford management opportunities that cannot be effectively replicated elsewhere. This publication presents management opportunities for all 16 ecological landscapes that are, collectively, designed to sustain as many species and community types as possible within the state, with an emphasis on those especially well represented in Wisconsin.

This document provides useful information for making management and planning decisions from a landscape-scale and long-term perspective. In addition, it offers suggestions for choosing which resources might be especially appropriate to maintain, emphasize, or restore within each ecological landscape. The next step is to use this information to develop landscape-scale plans for areas of the state (e.g., ecological landscapes) using a statewide and regional perspective that can be implemented by field resource managers and others. These landscape-scale plans could be developed by Wisconsin DNR staff in cooperation with other agencies and nongovernmental organizations (NGOs) that share common management goals. Chapter 1, "Principles of Ecosystem and Landscape-scale Management," contains a section entitled "Property-level Approach to Ecosystem Management" that suggests how to apply this information to an individual property.

How to Use This Chapter

The organization of ecological landscape chapters is designed to allow readers quick access to specific topics. You will find some information repeated in more than one section, since our intent is for each section to stand alone, allowing the reader to quickly find information without having to read the chapter from cover to cover. The text is divided into the following major sections, each with numerous subsections:

- Environment and Ecology
- Management Opportunities for Important Ecological Features
- Socioeconomic Characteristics

The "Environment and Ecology" and "Socioeconomic Characteristics" sections describe the past and present resources found in the ecological landscape and how they have been used. The "Management Opportunities for Important Ecological Features" section emphasizes the ecological significance of features occurring in the ecological landscape from local, regional, and global perspectives as well as management opportunities, needs, and actions to ensure that these resources are enhanced or sustained. A statewide treatment of integrated ecological and socioeconomic opportunities can be found in Chapter 6, "Wisconsin's Ecological Features and Opportunities for Management," in Part 1 of the book.

Summary sections provide quick access to information for important topics. "Central Sand Hills Ecological Landscape at a Glance" provides important statistics about and characteristics of the ecological landscape as well as management opportunities and considerations for planning or managing resources. "General Description and Overview" gives a brief narrative summary of the resources in an ecological landscape. Detailed discussions for each of these topics follow in the text. Boxed text provides quick access to important information for certain topics ("Significant Flora," "Significant Fauna," and "Management Opportunities").

Coordination with Other Land and Water Management Plans

Coordinating objectives from different plans and consolidating monetary and human resources from different programs, where appropriate and feasible, should provide the most efficient, informed, and effective management in each ecological landscape. Several land and water management plans dovetail well with *The Ecological Landscapes of Wisconsin*, including the Wisconsin Wildlife Action Plan; the Fish, Wildlife, and Habitat Management Plan; the Wisconsin Bird Conservation Initiative's (WBCI) All-Bird Conservation Plan and Important Bird Areas program; and the *Wisconsin Land Legacy Report*. Each of these plans addresses natural resources and provides management objectives using ecological landscapes as a framework. Wisconsin DNR ***basin*** plans focus on the aquatic resources of water basins and watersheds but also include land management recommendations referencing ecological landscapes. Each of these plans was prepared for different reasons and has a unique focus, but they overlap in many areas. The ecological management opportunities provided in this book are consistent with the objectives provided in many of these

plans. A more thorough discussion of coordinating land and water management plans is provided in Chapter 1, "Principles of Ecosystem and Landscape-scale Management," in Part 1 of the book.

General Description and Overview

The Central Sand Hills Ecological Landscape is located in central Wisconsin at the eastern edge of what was once Glacial Lake Wisconsin (see Figure 3.14 in Chapter 3, "Comparison of Ecological Landscapes"). The landforms in this ecological landscape are a series of glacial moraines that were later partially covered by glacial outwash. The area is characterized by a mixture of farmland, woodlots, wetlands, small ***kettle lakes***, and coldwater streams, all on sandy soils. The ***mosaic*** of glacial moraine and ***pitted outwash*** throughout this ecological landscape has given rise to extensive wetlands in the outwash areas and the headwaters of coldwater streams that originate in glacial moraines. The growing season is long enough for row crops, but the sandy soils limit agricultural productivity somewhat.

Historical upland vegetation consisted of oak forest, oak savanna, and tallgrass prairie. Fens were common here and occurred along with wet-mesic prairie, wet prairie, and rare coastal plain marshes. Current land cover is composed of more than one-third agricultural cropland and almost 20% grasslands (not native prairie) with smaller amounts of open wetland, open water, shrubs, barren (meaning "unvegetated," not to be confused with "barrens"), and urban areas. The major forested type is oak-hickory with smaller amounts of white-red-jack pine, maple-basswood, lowland hardwoods, aspen-birch, and spruce-fir. Black spruce (*Picea mariana*) is a component of the Corning-Weeting lakes wetland complex in the northwestern corner of Columbia County. This is one of the southernmost locations for black spruce in the Upper Midwest.

In some parts of the Central Sand Hills, there are small kettle lakes and ponds associated with glacial outwash landforms. There are many soft-water lakes with sand bottoms that have been or are being developed for residential and recreational uses. Green Lake occurs here and is the deepest natural lake in the state. Large, shallow impoundments include Lake Wisconsin on the Wisconsin River and Buffalo Lake and Lake Puckaway on the Fox River. Among the important rivers are segments of the Wisconsin, the lower Baraboo, and the upper Fox. Water quality in free-flowing rivers and streams is generally good. Water quality in these streams is enhanced by spring flows, the absence of point source discharges, and either minimal agricultural activity or well-maintained stream ***buffers***. Urban nonpoint runoff, sedimentation, excess nutrients, and heavy recreational boating use impact lake water quality and habitat.

The total surface area (includes land and water) of the Central Sand Hills Ecological Landscape is approximately 1.4 million acres, of which 28% is classified as ***timberland***. Only about 4% of the ecological landscape is in public ownership.

Although soils are predominantly dry and sandy, the Central Sand Hills counties are primarily agricultural. Agriculture in this sandy area often uses irrigation, mainly in the production of potatoes, sweet corn, peas, and snap beans. There is a considerable amount of marginal and idle agricultural land. There is one state park (Hartman Creek) in the ecological landscape as well as 26 ***state natural areas*** and 24 state fishery and state wildlife areas. Federal lands include Fox River National Wildlife Refuge, ***Waterfowl Production Areas*** of the Leopold Wetland Management District including the Lower Baraboo River Waterfowl Production Area, and several segments of the Ice Age Trail.

The Central Sand Hills counties are nearly "average" for most socioeconomic indicators. The population density (62 persons per square mile) is slightly more than half that of the state as a whole (105 persons per square mile). The region has shown an above average population growth rate since 1970, especially in people over 65. The number of minorities is low. Although average wage and per capita income are well below the state average, these indicators are intermediate compared to other landscape approximations. In addition, the rates of poverty and unemployment are well below average when compared to other regions. The agricultural and government sectors have a more influential role in the number of employees in the Central Sand Hills counties, whereas manufacturing and the service sector are less important than elsewhere in the state.

Environment and Ecology

Physical Environment

Size

The Central Sand Hills Ecological Landscape encompasses 2,170 square miles (1,388,705 acres), representing 3.9% of the area of the state of Wisconsin.

Climate

Climate data were analyzed from five weather stations within the Central Sand Hills Ecological Landscape (Dalton, Montello, Portage, Prairie du Sac, and Ripon; WSCO 2011). The Central Sand Hills has a continental climate, with cold winters and warm summers, similar to other southern ecological landscapes (Central Lake Michigan Coastal, Central Sand Plains, Southeast Glacial Plains, Southern Lake Michigan Coastal, Southwest Savanna, Western Coulees and Ridges, and Western Prairie). The southern ecological landscapes in Wisconsin generally tend to have longer growing seasons, warmer summers, warmer winters, and more precipitation than the ecological landscapes farther north. Ecological landscapes adjacent to the Great Lakes generally tend to have warmer winters, cooler summers, and higher precipitation, especially snow.

The mean growing season here is a 148 days (base 32°F), ranging from 139 to 158 days. This is similar to the mean growing season for other ecological landscapes in southern Wisconsin (152 days). Variation in growing season length (19 days) followed a latitudinal gradient, with weather stations farther north having fewer growing degree days.

Mean annual temperature is 45.5°F, very similar to other ecological landscapes in southern Wisconsin (45°F). The mean annual temperature varied little among weather stations within this ecological landscape (1.6 degrees). Average January minimum temperature is 4.1°F, and average August maximum temperature is 81.2°F, very similar to other southern Wisconsin ecological landscapes.

Mean annual precipitation is 32.8 (31–34.5) inches, similar to the mean annual precipitation of other southern ecological landscapes (33.1 inches). The mean annual precipitation varied little (3.5 inches) among weather stations within this ecological landscape. Mean annual snowfall is 38.7 inches. This is the lowest amount of annual snowfall for any ecological landscape in the state. The amount of annual snowfall varied considerably among weather stations within the ecological landscape, more than 23 inches (ranging from 25 inches to 48.3 inches). Prairie du Sac weather station reported almost 14 inches less snowfall than the mean annual snowfall of the other weather stations within this ecological landscape and more than 23 inches less than the weather station with the most snowfall (Dalton) in this ecological landscape. Part of this variability is likely due to observer differences and optional methods employed at some volunteer weather stations (Kunkel et al. 2007).

The climate (temperature, growing degree days, and precipitation) is suitable for agricultural row crops, small grains, and pastures. Thirty-four percent of the land cover in this ecological landscape was classified as agricultural in 1992, and another 19% was grassland (WDNR 1993), which is primarily pasture. Wetlands have often been drained and used for agriculture here. The sandy soil limits agriculture in parts of this ecological landscape.

Bedrock Geology

Bedrock geology in the Central Sand Hills Ecological Landscape has not been thoroughly investigated, and there is not a compiled source that provides information about the entire area. Sauk County, although a small part of the ecological landscape, has a detailed discussion of bedrock characteristics (see Clayton and Attig 1990). Paleozoic bedrock layers are similar throughout southern Wisconsin, so information about them is extrapolated from areas where descriptions are complete. Precambrian bedrock has been described by Smith (1978a, 1978b). (Nomenclature used herein is according to the Wisconsin Geological and Natural History Survey Open-File Report *Bedrock Stratigraphic Units in Wisconsin;* WGNHS 2006.)

Most of the ecological landscape is in the Cambrian sandstone lowland (Schultz 2004), where erosion prior to the Pleistocene removed much of the sandstone surface. Cambrian sandstones with some strata of dolomite and shale are the uppermost bedrock layers in most of the Central Sand Hills. However, the northernmost portion in Portage County is underlain by granitic rocks of the Wolf River Batholith, and the far eastern edge, in Green Lake and Winnebago counties, is underlain by Ordovician dolomite (WGNHS 2005).

The oldest bedrock mostly lies below the Cambrian sandstone, except in parts of Portage County and in occasional outcrops where it is the uppermost bedrock layer. These ancient rocks are Precambrian granite, rhyolite, and quartzite, along with lesser amounts of other metamorphosed igneous rocks, all of them more than a billion years old. Most of the rhyolite is relatively resistant to erosion, being fine-grained and dense, and so it forms some of the highest outcrops (Smith 1978b). The Precambrian surface slopes downward to the east and south at about 20 feet per mile. Its surface is higher in the northern part of the ecological landscape, closer to the ***Wisconsin Dome***, where it occurs at an elevation of about 700 feet above sea level and within about 400 feet below the land surface (Summers 1965, Smith 1978b). In Dane County, its elevation is about 100 feet above sea level. Occasional outcrops are at elevations of 900 to 1,100 feet (e.g., rhyolite at Observatory Hill in Marquette County and granite at Redgranite mound in Waushara County), so the depth to Precambrian bedrock is variable. Maps of Precambrian geology and elevations of the Precambrian surface are shown in Smith (1978b).

Paleozoic bedrock (including Cambrian and Ordovician deposits) is made up of sandstones, dolomite, siltstone, and shale (Figure 9.1). Cambrian deposits are about 280 feet thick in Waushara County, around 700 feet thick in Columbia and Dane counties, and up to about 300 feet thick in eastern Sauk County (Summers 1965, Harr et at. 1978, Clayton and Attig 1990, Clayton and Attig 1997). Ordovician rocks are absent in nearly all the ecological landscape, having been eroded prior to the Pleistocene. They occur only along the far eastern edge of the ecological landscape in small areas of Green Lake and Winnebago counties (WGNHS 2005).

The Paleozoic rock sequences were formed by cycles of marine deposition followed by erosion, occurring over approximately 80 million years. A description of these cycles and the marine conditions that led to the formation of different kinds of rock is given in LaBerge (1994). Paleozoic bedrock is similar throughout southern Wisconsin, so the rock types discussed here are comparable to those of the Central Sand Plains, Southeast Glacial Plains, and the Western Coulees and Ridges ecological landscapes (Dott and Attig 2004). Here, as throughout most of southern Wisconsin, Cambrian sandstones are important aquifers (Schultz 2004).

The oldest Paleozoic rock in the ecological landscape is Cambrian sandstone of the Elk Mound Group, deposited between about 523 and 510 million years ago when Cambrian seas first spread into Wisconsin from the south and west (WGNHS 2006). These seas eventually covered the entire

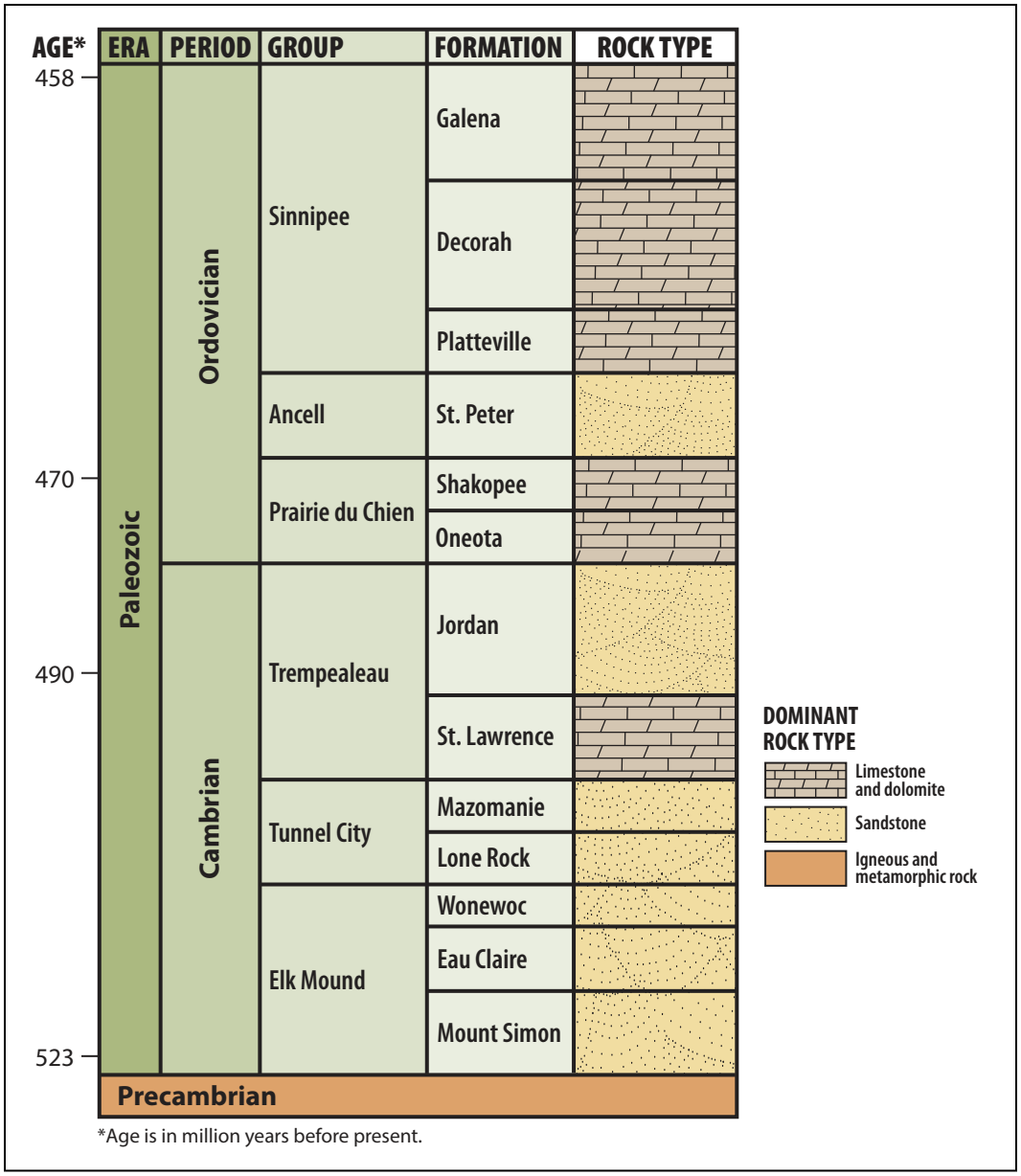


Figure 9.1. *Bedrock strata in the Central Sand Hills Ecological Landscape. Diagram based on Wisconsin Geological and Natural History Survey (2006).*

state but were shallower over the Wisconsin Dome (centered under the Northern Highland Ecological Landscape), and consequently the Cambrian bedrock thins as the Wisconsin Dome's surface rises. The Elk Mound Group includes the Mount Simon, Eau Claire, and Wonewoc formations. The Mount Simon Formation overlies Precambrian bedrock at the base of the Paleozoic sequence.

The Mount Simon Formation is a light colored, fine- to coarse-grained, thick-bedded sandstone with some dolomite and shale. It was deposited from a shallow marine environment as Cambrian seas advanced over the area (Schultz 2004). It is approximately 100 feet thick in northeastern Sauk County (Clayton and Attig 1990). The Eau Claire Formation is a thin, discontinuous layer due to erosion and lies above the Mount Simon Formation. It was deposited in a quieter marine environment as oceans rose and their depths increased. The Eau Claire Formation is fine- to medium-grained, thin- to medium-bedded, yellow or brownish sandstone, fossiliferous and contains shale. After this phase of deposition, the seas retreated, and the surface of the Eau Claire Formation was eroded (Schultz 2004). Above the Eau Claire Formation lies the Wonewoc Formation, deposited in nearshore environments as the seas readavanced under conditions similar to the deposition of the Mount Simon Formation. It is a thick layer of fine- to medium-grained, thick-bedded, brownish-yellow to yellow or white sandstone, likely deposited on broad tidal

flats (Thwaites et al. 1922). In northeast Sauk County, it is up to 75 feet thick (Clayton and Attig 1990).

The Wonewoc Formation grades gradually into the overlying Tunnel City Group. Rocks of this group include the Lone Rock Formation, a very fine- to fine-grained, glauconitic (i.e., micaceous, containing an iron silicate), thin- to medium-bedded light brown to green-brown sandstone. Fossils of trilobites and brachiopods can be found locally in this sandstone, indicating marine deposition. The discontinuous Mazomanie Formation occurs mostly along the Wisconsin Arch, which stretches south from the Wisconsin Dome through the ecological landscape (Mai and Dott 1985, Clayton and Attig 1990). It is made up of very fine- to medium-grained, pale brown, feldspathic and quartzose sandstone and sandy dolostone. Tunnel City rocks are 100 to 150 feet thick in Sauk County, outside the ecological landscape boundary (Clayton and Attig 1990).

The St. Lawrence Formation, part of the Trempealeau Group, occurs above the Lone Rock. It is about 300 feet thick in Sauk County (Clayton and Attig 1990). It was formed from sand and the shells of marine organisms and is dominantly a pale yellow dolomitic siltstone with beds of sandy material. A thin layer at the base is dolomite. The St. Lawrence Formation has a variable thickness, possibly due to irregularities of the underlying surface, variable deposition, or erosion following deposition. Fossils of trilobites and brachiopods can be abundant in the St. Lawrence but are mostly fragmented from transport before settling. Again, after this phase of deposition, the seas retreated and erosion of the surface occurred.

Jordan Formation sandstone overlies the St. Lawrence Formation. It is fine- to coarse-grained, light brown to brownish-yellow, moderately sorted, quartz-rich, thick-bedded sandstone that ranges in thickness, likely due to uneven deposition (Thwaites et al. 1922, Evans 2003). In Sauk County, outside of this ecological landscape, it is about 50 feet thick (Clayton and Attig 1990). It is not known to contain fossils, and this along with the pattern of bedding indicates that deposition may have occurred on a sandy flat covered by water at times, with some material deposited by wind.

Ordovician rocks overlying Cambrian deposits are found only in small areas near the eastern border of the ecological landscape. These include dolomite of the Oneota Formation of the Prairie du Chien Group. The Oneota Formation consists of very fine- to medium-crystalline, thin- to thick-bedded, pale gray to light brownish-gray dolomite, sandy dolomite, and dolomitic sandstone. The dolomite contains cavities in which calcite and quartz has developed, and chert is also abundant. Fossils of algal reefs (Cryptozoa) are common in the dolomite, and other fossils can be found in the chert. The Prairie du Chien's surface is dissected by erosion that occurred after this stage of deposition, and in most of the ecological landscape the deposit was completely removed (Schultz 2004).

The Ancell Group is next in the sequence but occurs only in small scattered areas in the far eastern part of the ecological landscape (Mai and Dott 1985). It lies over the Prairie du Chien Group (or other Cambrian layers, in locations where the uppermost rock layers were completely eroded). A layer of red clay and chert residuum between the Prairie du Chien and the Ancell provides additional evidence that weathering occurred for some time before deposition resumed. The Ancell Group is mostly sandstone of the St. Peter Formation, along with a thin layer of Glenwood Formation sandstone (although it is unclear whether any Glenwood occurs within the ecological landscape). The St. Peter Formation consists of fine to-medium-grained, pale brown, yellow or reddish, quartz-rich, thick-bedded sandstone with some limestone, shale, and conglomerate. It can form a thick layer in southern Wisconsin but in this ecological landscape was nearly all eroded.

A few outliers of Sinnipee Group dolomite may be found near the southwestern corner of Winnebago County in the far eastern tip of the Central Sand Hills Ecological Landscape and possibly in a few locations in Columbia and Green Lake counties, overlying the Ancell Group (Harr et al. 1978, WGNHS 2005). Sinnipee Group rocks are firm dolomites with some limestone and shale. They can be as much as 200 to 250 feet thick in eastern Wisconsin (Clayton 2001) but are thinner here due to erosion.

Bedrock exposures are limited in this ecological landscape but include several interesting localities. Granite of the Wolf River Batholith outcrops in a prominent mound near Redgranite in Waushara County and can be viewed at Flynn's Quarry County Park south of Lohrville (Summers 1965, Smith 1978a). A rhyolite outcrop at Observatory Hill, a state natural area in Marquette County, is described in detail by Smith (1978a). Cambrian sandstones form an outcrop near Mt. Morris in Waushara County (Summers 1965). A 100-foot-high exposure of Ordovician St. Peter sandstone, overlying Prairie du Chien dolomite and Cambrian sandstone, occurs at Gibraltar Rock, a state natural area north of Lodi in Columbia County (Dott and Attig 2004, Schultz 2004).

Landforms and Surficial Geology

The Central Sand Hills Ecological Landscape is covered in glacial deposits originating from the Green Bay Lobe during the late Wisconsin ice advance. The area is a diverse mix of moraines, drumlins, till plains, outwash features, and lake plains. Glacial sediment is typically 50 to 100 feet thick over bedrock, but its thickness varies from zero on bedrock outcrops to over 300 feet in preglacial valleys (Harr et al. 1978, Clayton and Attig 1990). Glacial till deposits in this ecological landscape are in the Holy Hill Formation.

Glacial ice has covered this area a number of times, but the late Wisconsin advance of the Green Bay Lobe removed the evidence of previous glaciations. The Green Bay Lobe moved in a south to southwestward direction through the low-lying and relatively soft sediments of Green Bay, expanding southward as far as Janesville and westward to the boundary between the Central Sand Hills and Central Sand Plains ecological landscapes. The Green Bay Lobe covered the entire

ecological landscape approximately 24,000 years ago and began melting about 19,000 years ago. A variety of glacial features were left behind when the ice had completely retreated from the area by about 12,000 years ago (approximate time frames for glacial events in this part of Wisconsin have been revised based on gamma radiation levels; previous C14 dating had identified more recent dates for some of these events [Hooyer 2007]). Moraines were formed when the glacial ice was at a standstill, with melting occurring at about the same rate as advance, so that the glacier stood in one place long enough to deposit a ridge of sediment. Moraines have a hummocky topography because ***supraglacial till*** (material on top of the ice sheet) was deposited unevenly in crevasses and other features along the melting ice margin, and also because overlying sediment collapsed when buried stagnant ice melted. The outermost moraine built by the Green Bay Lobe is known as the Johnstown Moraine (see the "End Moraine Deposits" map in Appendix G, "Statewide Maps," in Part 3, "Supporting Materials"), which forms a line of low hills running north-south along the western edge of the ecological landscape. A series of younger moraines lie parallel to the Johnstown, including the Hancock, Almond, Elderon, and Bowler/Green Lake moraines. These are lateral moraines, formed along the western margin of the glacial lobe as it melted back toward Green Bay. The Arnott Moraine, which forms a small sliver extending from the western edge of the ecological landscape, is a remnant moraine of a previous glaciation, likely Illinoian, that was not covered by the Wisconsin ice advance. Its topography is more subdued than recent moraines because of its longer weathering period.

During glaciation, ***tunnel channels*** were cut through the moraines by meltwater flowing out under pressure from the weight of the ice. A map by Colgan (2003) shows a number of channels along the edge of the Johnstown Moraine in Adams County, each one associated with an outwash fan where sediment carried by the meltwater was deposited. Such areas are often mined for sand and gravel (Clayton and Attig 1989).

The Central Sand Hills Ecological Landscape is made up of two Subsections that exhibit some important differences in glacial landforms. The Central Wisconsin Moraines and Outwash Subsection (222Kb) lies to the northwest, and the South Central Wisconsin Prairie and Savannah Subsection (222Kd) to the southeast (Cleland et al. 1997; for details on Subsections, see the "Introduction" in Part 1 of the book and also the "Ecological Landscapes, NHFEU Provinces, Sections, and Subsections" map in Appendix G, "Statewide Maps," in Part 3). The Central Wisconsin Moraines and Outwash Subsection is a diverse glaciated landscape that is a mix of moraines, outwash features, and lake plains. Between moraines, the area is covered in outwash sediment that flowed out of the melting ice and deposited sand and gravel over earlier till deposits. Outwash sediment was sometimes deposited on relatively level areas such as till plains and has a flat topography. In other cases, material was deposited over stagnant glacial ice and collapsed as the ice melted, creating hummocky topography on pitted outwash plains and collapsed ***heads-of-outwash***. Pitted outwash is extensive in parts of this Subsection, such as in the area east of Coloma (Dott and Attig 2004). Glacial lakes occurred in areas where glacial meltwater was held back by ice dams, bedrock ridges, and/or moraines, forming lake plains of accumulated sand and silt sediments. Extensive wetlands formed in the lower-lying outwash and lake plain areas, and the headwaters of many coldwater streams originate in the glacial moraines.

The South Central Wisconsin Prairie and Savannah Subsection is predominantly a glacial till plain. The landscape is undulating to hilly and includes drumlins in the northern part of the Subsection. Bedrock-cored knolls and hills occur in the southern part, including areas in the far south where much of the till has eroded off the underlying bedrock.

Till in the southeastern part of the Central Sand Hills is predominantly the Horicon Member of the Holy Hill Formation; it is a brown, sandy loam till widely deposited in southeast Wisconsin by the Green Bay Lobe and usually contains dolomite that was incorporated as the glacier moved over the ***Niagara Escarpment*** to the east (Clayton and Attig 1997). Till in the northwestern part is the Mapleview Member of the Holy Hill Formation. The Mapleview till is coarser-textured and contains less dolomite. The boundary between the Horicon and Mapleview members is uncertain but may correspond roughly with Subsection lines.

The South Central Wisconsin Prairie and Savannah Subsection is overlain by a silt-loam loess cap deposited by postglacial wind action, about 0.5 to 2 feet thick (Hole 1976). The Central Wisconsin Moraines and Outwash Subsection lacks a loess cap and has a surface that is predominantly sand.

The main basin of Glacial Lake Wisconsin lies in the Central Sand Plains, but for approximately 1,000 years, a portion of this glacial lake also existed in the Central Sand Hills. Glacial lake deposits occur in Columbia County northeast of the Baraboo Hills in the area known as the Lewiston basin (Harr et al. 1978). Southeast of the Baraboo Hills lies the lakebed of the smaller Lake Merrimac. Both of these glacial lakes formed during the Elderon Phase of the latter part of the Wisconsin glaciation, between about 15,000 and 14,000 years ago (Clayton and Attig 1989). Water was impounded behind the Johnstown Moraine as the ice sheet melted back toward the east from its maximum position, flowing out to the west through a low spot in the moraine at what is now Wisconsin Dells. The Lewiston basin was mostly drained at the same time as the catastrophic drainage of the main basin of Glacial Lake Wisconsin, when an ice dam at the eastern tip of the Baraboo Hills melted and was breached (Clayton and Attig 1989). However, the southern end of the lake in the Lewiston basin was approximately 50 feet below the outlet, so a lake remained in that area for some time after other parts of Glacial Lake Wisconsin had drained. Eminent conservationist Aldo Leopold's famous Shack is located within the area of the Lewiston basin on a river terrace formed when the Wisconsin River cut through the glacial lakebed after it drained.

Glacial Lake Oshkosh covered portions of the Central Sand Hills during the last phases of glaciation in southern Wisconsin. The lake formed when ice of the Green Bay Lobe stood in the Fox River lowland between present-day Lake Winnebago and Green Bay of Lake Michigan. Surface water draining northward through the lowland became impounded in front of the ice sheet until finding other outlets, either westward into the Wisconsin River, or eastward to the Michigan basin. The ice sheet readvanced at least two times after it had fully receded from Wisconsin, so there were three stages of Glacial Lake Oshkosh during ice retreat. The lake was at its largest extent at about 18,500 years ago when it occupied parts of Columbia, Marquette, Green Lake, Winnebago, and Waushara counties and drained through an outlet in Columbia County to the Wisconsin River. Readvances of the ice sheet at around 16,000 and 13,500 years ago partially refilled the glacial lake and again utilized the drainage to the Wisconsin River (Hooyer 2007). Glacial Lake Oshkosh left behind a nearly level lake plain formed by settling of fine-grained offshore sediment as well as beach terraces and ridges created by wave and ice action along former shorelines. As the lake dried, winds blowing across the lake plain deposited aeolian sand and formed dunes at some locations. Lake deposits can be viewed along Highway I-39, between the Columbia-Marquette County border north to the junction with Wisconsin State Highways 82 and 23 (Dott and Attig 2004). Most of the area formerly covered by Glacial Lake Oshkosh lies within the Southeast Glacial Plains Ecological Landscape.

Following glaciation, erosion and redeposition due to surface water flow formed floodplains and terraces along the larger streams and rivers. The many wetlands that occur in the ecological landscape are largely due to impeded drainage caused by the underlying fine-textured glacial till and lake sediments.

A map showing the Landtype Associations (Wisconsin Landtype Associations Project Team 2002) in this ecological landscape, along with the descriptions of the Landtype Associations, can be found in Appendix 9.K at the end of this chapter.

Topography and Elevation

Topography in the Central Sand Hills ranges from nearly level on outwash and lake plains to undulating and hilly on drumlins, remnant moraines, and bedrock-cored hills. Elevations range from about 738 feet at the southern edge of Sauk City along the Wisconsin River to 1316 feet at the top of a sandstone-cored hill in the northwest corner of Marquette County. Elevations of the general land surface are higher toward the north.

Soils

Soils of the Central Sand Hills are primarily sands in the northwestern portion (Central Wisconsin Moraines and Outwash Subsection) and sandy loam tills in the southeast (South Central Wisconsin Prairie and Savannah Subsection). Organic soils occur in wetlands throughout the ecological landscape. The major river valleys have soils formed in sandy to clayey alluvial material or non-acid muck. Their drainage classes range from moderately well drained to very poorly drained, and some areas are subject to periodic flooding.

In the Central Wisconsin Moraines and Outwash Subsection, most soils formed in sandy glacial till, outwash, or lacustrine materials. The dominant soil has a loamy sand surface over sand, is well drained with rapid permeability, and has a low available water capacity. Some areas have calcareous material. Soil drainage classes range from excessively drained to somewhat poorly drained, and soils generally have loamy sand to sandy loam surface textures, moderate to very rapid permeability, and moderate to low available water capacity. Lake plain soils were formed in lacustrine sediments of a variety of textures, ranging from sandy to clayey. These soils have drainage classes that range from well drained to somewhat poorly drained, and they generally have loamy fine sand to silt loam surface textures, rapid to very slow permeability, and low to high available water capacity. Most wetlands have very poorly drained non-acid muck, poorly drained outwash, or poorly drained sandy to clayey lacustrine soils.

Most soils of the South Central Wisconsin Prairie and Savannah Subsection formed in brown calcareous sandy loam till on moraines and drumlins. The dominant soil is well drained and loamy with a fine sandy loam surface, moderate permeability, and moderate available water capacity. Soil drainage classes range from well drained to somewhat poorly drained, and soils generally have fine sandy loam to silt loam surface textures, moderate to moderately rapid permeability, and moderate available water capacity. These soils are fertile, and much of the land is used for agriculture. Some upland areas have soils formed in loamy deposits over noncalcareous sandy glacial till, in acid to calcareous outwash sand and gravel on moraines and outwash plains, and in loamy to sandy material over sandstone or limestone bedrock. These diverse soils range from excessively drained to somewhat poorly drained and generally have loamy sand to silt loam surface textures, moderate to very rapid permeability, and moderate to low available water capacity. Most wetland soils are very poorly drained non-acid muck, outwash, or loamy till.

Hydrology

The Central Sand Hills Ecological Landscape contains an interesting hydrological circumstance in that the south-flowing Wisconsin River and north-flowing Fox River pass within 2 miles of each other, just east of present-day town of Portage. Early accounts indicate that during floods, the overflow of the Wisconsin River would flow down the channel of the Fox River (USACE 1977, Wisconsin Historical Society 2011), providing a mechanism for fishes and other aquatic organisms to move between the Mississippi and Lake Michigan basins (31990). This had important zoogeographic implications. The distribution of a number of aquatic species in the Lake Michigan basin seems to have been influenced by the "natural" connection at Portage to the Mississippi River basin.

Historically, the close proximity of these two major waterways also allowed for a natural portage between them—a key link in a human travel and trade route that connected Lake Michigan, the Saint Lawrence River, and the northern Atlantic Ocean with the Mississippi River and Gulf of Mexico. In the mid-1800s, this Fox-Wisconsin waterway was altered with numerous locks, dams, and canals, including the 2-mile Portage Canal between the Fox and Wisconsin rivers (Portage Canal Society 2009). Construction of the canal made fish movement between the Fox and Wisconsin rivers even easier.

While construction on the Portage Canal began in 1838, it was not completed until 1876, well after freight began moving primarily by railroad. The Fox River at this point also proved too small and meandering for efficient commercial use. Later development on the waterway introduced barriers to navigation, such as the dam at Prairie du Sac. Use of the waterway for commerce was never substantial, and it slowly faded away. The Portage Canal was closed in 1951. The lock system on the lower Fox River, from Lake Winnebago to Green Bay, was closed in 1983 to prevent the upstream spread of invasive species such as sea lamprey.

There are nearly 400 ***high capacity wells*** in the Upper Fox River basin. While the majority of these wells are farther east in the Lake Winnebago region of the Southeast Glacial Plains Ecological Landscape, the increasing use of high capacity wells for agriculture and other purposes creates concerns for groundwater quantity. High capacity wells near groundwater discharge areas (wetlands, springs, streams, etc.) have the potential to intercept enough groundwater to diminish water flow from springs and reduce stream flows. Over time, these groundwater-dependent areas can eventually become depleted. This can also alter the ecology of wetlands, which are the headwaters of many streams. A high concentration of ***private wells*** may have similar ecological impacts, so wise land use planning and siting of wells is needed to prevent natural resource harm.

Basins

The Central Sand Hills Ecological Landscape overlies portions of five water basins: the Upper Fox (the west half), Lower Wisconsin (the far southeastern portion), Wolf River (the far southwestern crescent), Central Wisconsin (a thin sliver on the western edge), and Upper Rock (a small point in the west-central portion) basins. Approximately 60% of this ecological landscape is within the Upper Fox River basin. Within these basins, there are 27 watersheds that lie entirely or partially within this ecological landscape (see Appendix 9.A).

Inland Lakes

According to the Wisconsin DNR's 24K Hydrography Geodatabase (WDNR 2015b), there are 231 named lakes in this ecological landscape totaling 16,674 acres and 3,556 unnamed lakes (mostly small lakes) totaling 5,452 acres. Lakes here vary from very broad and shallow drainage lakes in wetland settings to the deepest inland lake in Wisconsin. Inland lakes in the Central Sand Hills often comprise part of a complex with uplands and lowlands in a heterogeneous mosaic.

A large proportion of lakes in the Central Sand Hills Ecological Landscape are seepage lakes, lacking any in-flowing or out-flowing streams. In the Waushara County portion of this ecological landscape, a vast majority of lakes are seepage lakes (including larger lakes of 50 to over 100 acres such as Norwegian, Big Hills, Huron, Napowan, Round, Pine, Plainfield, Sand, Twin, Pleasant, and Gilbert). Dependent primarily on groundwater flow (augmented by rainfall runoff) for a water supply, seepage lakes can exhibit great fluctuations in water levels. Water level fluctuations during drought periods can be extreme, and some seepage lakes exhibited dry lake beds in the Central Sand Hills in the 1930s and 1950s, even before the advent of high capacity wells (Roost and Cason 2007).

Seepage lakes also tend to be in watersheds of very permeable, sandy soils where groundwater can bring excessive amounts of nitrogen derived from agricultural sources into a lake, which can fuel excessive growth of weeds (Roost and Cason 2007). The nature of these seasonal and annual water level fluctuations enables a few of these lakes to support occurrences of the globally rare Coastal Plain Marsh community, which would be overgrown with trees and shrubs or entirely inundated were it not for the cyclical variation in water levels.

Small kettle lakes occur here located in ground moraine and collapsed glacial outwash and include Ennis, Madden, and the chain of three Thompson lakes. As described in 1963, these kettle lakes tended to be clear and fertile, some with small outlet streams and some hosting populations of panfish, northern pike (*Esox lucius*), and largemouth bass (*Micropterus salmoides*) (WCD 1963). A few of these lakes remain undeveloped and have no public access, which helps maintain good water quality and an unbroken connection to the uplands. As of 1970, changes in land use created concerns regarding the need to protect water quality and habitat values (Fassbender et al. 1970), which were gradually addressed through lake management planning. Beginning in 2011, Waushara County initiated a lake protection planning project to update existing lake management plans for 33 lakes with public access (WCDZLC 2015).

Largest of all lakes in this ecological landscape, Green Lake (7,346 acres) has a depth of 236 feet and is the deepest natural inland lake in Wisconsin. Bottom materials include sand and rubble. Several stands of emergent macrophytes, such as beds of hard-stem bulrush (*Schoenoplectus acutus*), were identified while conducting ***critical habitat*** surveys to determine if sites should be designated as Sensitive Areas. Because of a largely developed shoreline, Green Lake receives heavy use from people who enjoy a full range of water sports and other water-based activities. It has been impacted locally by the invasive Eurasian water-milfoil (*Myriophyllum spicatum*) and in some areas by curly-leaf pondweed (*Potamogeton crispus*), zebra mussel (*Dreissena polymorpha*), and common carp (*Cyprinus carpio*). Carp barriers have been installed to

reduce negative impacts on deepwater marsh spawning areas and aquatic vegetation at the north and south ends of the lake, and a netting program removes about 100,000 pounds of carp per year. While overall water quality has remained good, there has been a gradual downward trend toward eutrophic conditions from winter manure spreading in the watershed, degraded tributary streams, shoreline urbanization, nutrient-laden wastewater discharge from the city of Ripon, and other sources (Sensing 2013).

Big (78 acres) and Little Twin (33 acres) lakes are drainage lakes with ***marl*** bottoms. Spring Lake (67 acres) is spring fed and supports a diverse assemblage of native aquatic plants species, with a good population of largemouth bass as well as stocked trout. Little Green Lake (466 acres) is negatively impacted by surrounding agricultural and residential land uses, with 82% of its watershed in agricultural land use and only 11% in wetland and forest cover. Excessive nutrients result in high algae densities, low Secchi depth readings, decreased dissolved oxygen levels, and dense growths of invasive Eurasian water milfoil and curly leafed pondweed. In-lake nutrient recycling accounts for much of this problem (GLCLCD 2004). Despite these impairments, it supports populations of muskellunge (*Esox masquinongy*), walleye (*Sander vitreus*), and panfish.

Swan Lake is a natural 406-acre lake on the Fox River. It has a maximum depth of 82 feet, an average depth of 32 feet, and good water quality. There is concern over the impact of an expanded gizzard shad (*Dorosoma cepedianum*) population, which is suppressing the community of zooplankton that eats algae. The lake's water volume has masked any serious symptoms of this problem (CCLWCD 2011). The much shallower impoundment just upstream, Park Lake, with an even greater overabundance of gizzard shad, is eutrophic, exhibits extensive algal blooms, and has suffered a severe loss of desirable sport fish (WDNR/PLMD 2007).

Impoundments

Small dams are common here, and many streams have been impounded. One hundred seventy dams on Central Sand Hills streams have created 26,566 acres of impoundments of varying sizes (WDNR 2015b). These store more than 154,420 acre-feet of water. Erosion, sediment build-up, and excess nutrient loads impact impoundment habitats. Sixteen dams have been removed for safety or economic reasons. A number of dams are viewed locally as important for maintaining habitat for common sport fish and waterfowl species such as northern pike, walleye, and Canada Geese (*Branta canadensis*).

Lake Wisconsin, a 9,000-acre impoundment on the Wisconsin River, was created by the Prairie du Sac Dam. It is the largest impoundment in this ecological landscape and has a maximum depth of 39 feet. This impoundment warms the water, slows the river's flow, and blocks migration essential to several fish species. In addition, it traps sediments and prevents the river from flushing them from its channel. This, in turn, causes excess agricultural nutrients and other pollutants, including lead, mercury, and ***polychlorinated biphenyls*** (PCBs) to accumulate within the impounded area and contributes to heavy algae growth, chronic oxygen depletion, and bioaccumulation of PCBs at concentrations that make some fish (e.g., lake sturgeon) unsafe to eat.

Grand River Marsh is 7,000 acres in size and is one of the primary features of the Grand River Wildlife Management Area, a major resting place for migratory waterfowl and breeding location for wetland birds. Grand Lake, upstream of Grand River Marsh near Kingston, is 234 acres in size with a maximum depth of 8 feet and an overly dense aquatic plant community due to high nutrient inputs from agricultural sources.

Park Lake at Pardeeville (Columbia County) is a 312-acre impoundment on the upper Fox River, with a maximum depth of 17 feet and an average depth of 7 feet. It supported a healthy and diverse fish population and was popular with anglers through the mid-1990s. Over time, excessive inputs of phosphorous, other nutrients, and chemicals from surrounding (predominantly agricultural) land uses created a highly eutrophic lake with excessive and undesirable native and nonnative invasive aquatic plant growth and algal blooms. Continued expansion of the carp population, possibly in combination with wind stirring up bottom sediments in expansive shallow areas, increased the turbidity, which eliminated the growth of diverse native aquatic vegetation in water deeper than 3 feet. This in turn greatly simplified the fish assemblage by eliminating much of the bluegill and bass population to the point where pollution-tolerant carp, shad, and channel catfish (*Ictalurus punctatus*) now dominate the fishery. A lake district and several public agencies have developed both a lake rehabilitation plan and a lake restoration implementation plan to address these problems (PLMD 2007, PLMD 2012).

Lake Puckaway is enlarged by a lock and dam on the Fox River near Princeton. Just 2 miles west of Green Lake, Puckaway was a wide, shallow marsh along the Fox River until the lock and dam impounded it in the late 1800s. After that, water level fluctuations, wave action, carp invasion, dredged access channels from the shore, and excessive agricultural sediments and nutrients destroyed or degraded once-thriving populations of wild rice (*Zizania* spp.), several bulrush species (*Schoenoplectus* and *Scirpus* spp.), bur-reeds (*Sparganium* spp.), and other desirable plants. The once-clear water now exhibits high turbidity and algal blooms (LPPRD 2004).

The lock and dam was constructed as part of a system of locks and dams on the Fox River to allow steamboat access from Lake Butte des Morts to the Portage Canal, connecting the Fox and Wisconsin rivers. Although the locks are no longer functioning, the low dam (2 feet of hydraulic head) creates the Lake Puckaway impoundment of 5,040 acres, 7 miles upstream. Lake Puckaway would still exist without the dam, but it would average only 1 foot deep and have a maximum depth of only 3 feet. With the dam, Lake Puckaway has a maximum depth of 5 feet. Despite its many alterations, Lake Puckaway supports populations of sport fish, including

walleye and northern pike as well as panfish. It is well known for its Sandhill Crane (*Grus canadensis*) population and is frequently used by migratory waterfowl. A comprehensive management plan has been approved to address a wide range of problems (LPPRD 2009).

Buffalo Lake in Marquette County is a widening of the Fox River that was created by a low rock-fill dam. This impoundment of 2,179 acres has undergone heavy shoreline development. Excess nutrients have created dense, undesirable vegetation that hampers navigation. A local lake management association is working to control this undesirable vegetation caused by excess nutrients. A small population of lotus (*Nelumbo lutea*), a rare, aesthetically pleasing aquatic macrophyte of limited distribution in Wisconsin, occurs here. This attractive plant is known mostly from a few backwaters of the Mississippi River, several sites on the lower Wolf River, and at scattered locations on other large, warmwater rivers or impoundments in southern Wisconsin.

Mason Lake at Briggsville is an 882-acre impoundment on a tributary of Neenah Creek. It has a maximum depth of only 8 feet and supports a largemouth bass fishery. It has poor water clarity in summer, with ***Secchi disk*** readings of less than 2 to 3 feet due to heavy algal blooms.

Rivers and Streams

Approximately 1,124 miles of perennial rivers and streams of all sizes and classifications flow in the Central Sand Hills Ecological Landscape (WDNR 2015b). The middle Wisconsin, upper Fox, and lower Baraboo rivers are the major flowing waters in this ecological landscape, but these rivers have had a long history of being negatively impacted by past and present land uses and resulting water quality degradation. Other significant streams here include the Grand, Mecan, Montello, and White rivers. A large number of coldwater streams and communities occur in the north central portion of the ecological landscape.

The Central Sand Hills contains a concentration of more than 100 coldwater streams that originate in a moraine (the Johnstown Moraine—see the "Bedrock Geology" section of this chapter), where calcareous material influences the mineral content of the streams. These streams are associated with wetlands such as sedge meadow, shrub swamp, and calcareous fen. Many of these streams are popular trout waters, with both native brook trout (*Salvelinus fontinalis*) and nonnative brown trout (*Salmo trutta*), and include Rowan, Rocky Run, Spring, Big Spring, Lawrence, Bird, Bowers, Lunch, Soules, Chaffee, Big Roche a Cri, Black Earth, Bear, Willow, Klawitter, Wedde, Emmons, and Lunch creeks as well as Pine River, upper White River, West Branch of the White River, and the upper Mecan River. About two-thirds of these streams are either ***Outstanding Resource Waters (ORW)*** or ***Exceptional Resource Waters (ERW)***.

The Wisconsin River is by far the largest warmwater river in this ecological landscape. It is free flowing in this ecological landscape for approximately 25 miles, from below the Kilbourn Dam at Wisconsin Dells downstream to the slack water of Lake Wisconsin, which is impounded by the Prairie du Sac Dam. The Kilbourn Dam on the Wisconsin River at Wisconsin Dells operates as a ***run-of-the-river*** plant, producing a maximum of 10 megawatts of electricity from 10 A.M. to 3 P.M. The Prairie du Sac Dam also operates as a run-of-the-river facility to provide electrical energy. Both pose a barrier to the movement of fish and other aquatic species. Daily water level changes in this stretch of the river are controlled by the Castle Rock dam upstream of this ecological landscape, which is operated as a peaking facility. Release of water by the Castle Rock dam can cause water levels on the river downstream to rise quickly. These changes in water levels can have a negative effect on water quality and fish habitat due to increased bottom scouring, bank erosion, and the flushing of spawning areas. Areas used by birds, herptiles, and invertebrates can also be adversely affected.

Dissolved oxygen depletion has been noted in the Wisconsin River below the Prairie du Sac dam due to runoff of excessive nutrients from the watershed into Lake Wisconsin above the dam. These problems were addressed through a comprehensive water quality plan as part of the Federal Energy Regulatory Commission (FERC) relicensing process for the Prairie du Sac dam. There is a requirement in place to provide fish passage both upstream and downstream of the dam by 2015 using a fish elevator at this dam site (Lamoreaux 2014, USFWS 2015), but there is concern that the fish elevator would allow Asian carp to enter the upper ***reaches*** of the Wisconsin River.

The Baraboo River is now one of the longest free-flowing rivers (120 miles) east of the Mississippi River since the removal of several dams in the 1990s. The lower 14 miles of this river are within this ecological landscape, and much of it is in a heavily meandered, complex floodplain at the confluence with the Wisconsin River. This connection to the Wisconsin River helps to make aquatic life in the Baraboo River much more diverse than it would be if the dams were in place.

The Fox River is a small stream with a low gradient in this ecological landscape. An 1855 account of the Fox River, in what is now Green Lake County, describes the river as having clear water that supported smallmouth bass (*Micropterus dolomieu*) and wild rice. The water in this stretch of the Fox River is presently turbid due to erosion from farm fields and the drainage of wetlands. Heavy siltation of the bed of the Fox River makes it no longer suitable for supporting sensitive invertebrates. The river still has a popular warmwater sport fishery, but the abundance of carp is a problem (WDNR 2001). Two former navigation dams and their locks have been removed from the Fox River within the Central Sand Hills. These were downstream from Montello and below Princeton. The Wisconsin DNR has been conducting long-term trend water quality monitoring on the Fox River at Berlin, where there is also a U.S. Geological Survey river flow station.

A number of other warmwater streams originate in or flow through this ecological landscape. These streams typically do

not have the flow volume or habitat diversity of rivers like the Wisconsin or Fox but do support valuable populations of ***nongame*** fish and limited populations of warmwater sport fish. Warmwater streams here include the Montello, Puchyan, lower Crystal, and White rivers.

Springs

Springs, spring runs, and seepages are common along the edge of the Johnstown Moraine and provide habitat for rare plants and invertebrates as well as a coldwater recreational fishery. There are 265 springs documented in this ecological landscape (Macholl 2007). A majority of these originate in glacial moraines and contribute to the persistent flow and high quality of coldwater streams. High capacity irrigation wells, which have become more common in the vegetable production areas of the ecological landscape since the 1980s, may jeopardize the continued flow of springs. Streamside wetlands fed by alkaline groundwater originating in the calcareous material of the moraines are characteristic of a number of streams, including the Mecan River and Caves, Chaffee, Klawitter, Lawrence, Snake, and Wedde creeks.

Wetlands

According to Wisconsin Wetlands Inventory data (WDNR 2010c), the Central Sand Hills Ecological Landscape contains more than 254,000 acres of wetlands. This is about 18% of the total area of the ecological landscape. The Central Sand Hills has the eighth largest number of acres of wetlands and the seventh highest percentage of wetlands (18%), compared to other ecological landscapes. More than 107,000 acres are forested wetlands, over 81,500 acres are emergent/wet meadows, nearly 57,000 acres are shrub-scrub wetlands, and almost 3,700 acres are aquatic bed wetlands.

Marshes, sedge meadows, fens, shrub swamps, and tamarack (*Larix laricina*) swamps are among the important wetland communities occurring here. Sedge meadows, fens, and tamarack swamps are especially sensitive to hydrological alterations, including the disruption of moving groundwater (both volume and quality). Floodplain forests are locally important on stretches of the larger rivers, such as the Wisconsin, Fox, and Baraboo and, to a lesser extent, the Montello and the White (upstream of northwest Green Lake County) (Galvin et al. 2002).

Marshes are common in and along the edges of some shallow lakes and impoundments. Coastal Plain Marsh is a globally rare herb-dominated wetland community that is significant for the rare plants and invertebrates it supports. Among the latter are rare dragonflies such as the spatterdock darner (*Rhionaeschna mutata*), ringed boghaunter (*Williamsonia lintneri*), sand snaketail (*Ophiogomphus smithi*), and warpaint emerald (*Somatochlora incurvata*). Occurrences of the Coastal Plain Marsh in Wisconsin are limited to a few counties, all with sandy soils, small sand-bottomed seepage lakes, and proximity to extensive glacial lakes during the last ice advance.

Southern Sedge Meadow (foreground) and Emergent Marsh (background). Marquette County. Photo by Eric Epstein, Wisconsin DNR.

Several major wetlands are largely in public ownership, including Germania/Comstock Marsh, Grand River Marsh, and White River Marsh (only a small portion of which is in this ecological landscape). Other smaller wetland sites, such as Duck Creek, are managed as part of other state wildlife and fishery management areas. Some privately owned wetlands have been ditched and drained for agriculture.

There are some important wetland complexes along streams in the Upper Fox River basin, including Page Creek Marsh. This site supports several rare plant species, including downy willow-herb (*Epilobium strictum*) and slim-stem reed-grass (*Calamagrostis stricta*). Wild rice still occurs along some stretches of the Montello River (WDNR 2001). The extensive Snake Creek corridor contains a wide zone of tamarack swamp and sedge meadow, several miles of which is now under conservation protection. Harrington Creek is a small tributary of the Fox River on the southern edge of the village of Berlin. The stream flows through a large wetland that includes a calcareous fen complex.

Agriculture is the primary land use in this ecological landscape, and many wetlands have been drained by networks of ditches that eventually discharge to natural waterways. Drained wetlands here have often been used for muck farming and grazing. Ditching has altered the hydrology and vegetation, destroying natural wetlands and important wildlife habitat. Drainage ditches in areas that are no longer actively farmed prevent the reestablishment of natural ecosystems. Drainage and fire suppression in some open wetlands and tree cutting in forested wetlands in this ecological landscape have converted some of them to shrub swamp.

Water Quality

As with most areas of the state, there is a wide range of water quality values in the streams and lakes in the Central Sand Hills. Water quality in free-flowing rivers and streams as well as in many natural lakes is generally good.

Outstanding Resource Waters (ORW) or Exceptional Resource Waters (ERW) are surface waters that have good

water quality, support valuable fisheries and wildlife habitat, provide outstanding recreational opportunities, and are not significantly impacted by human activities. Waters with ORW or ERW status warrant additional protection from the effects of pollution. Both designations have regulatory restrictions, with ORWs being the most restrictive. These designations are intended to meet federal Clean Water Act obligations and prevent the loss of water quality or degradation of aquatic habitats. They are also used to inform and guide land use changes and human activities near these designated waters. A number of streams, including roughly 60 coldwater streams, are designated ORW/ERW waters. Water quality in these streams is enhanced by spring flows, the absence of point source discharges, and either minimal agricultural activity or well-maintained stream buffers. There are also five lakes listed as ORW/ERW waters: Gilbert, Lucerne, Crystal, Norwegian, and Pine lakes. A complete list of ORW and ERW in this ecological landscape can be found on the Wisconsin DNR website (WDNR 2015d).

Waters designated as impaired on the ***U.S. Environmental Protection Agency (EPA) 303(d) list*** exhibit various water quality problems, including PCBs in fish, sediments contaminated with industrial metals, mercury from atmospheric deposition, bacteria from farm and urban runoff, and habitat degradation. Since the 303(d) designation is narrowly based on the criteria above, a waterbody could be listed as a 303(d) water as well as an ORW or ERW; the designations are not mutually exclusive. A plan is required by EPA on how 303(d) designated waters will be improved by the Wisconsin DNR. This designation is used as the basis for obtaining federal funding, planning aquatic management work, and meeting federal water quality regulations.

Ten lakes are designated as 303(d) water quality impaired waters: Silver Lake, Lake Wisconsin, Little Green Lake, Park Lake, Mason Lake, Hills Lake, Kusel Lake, Green Lake, Lake Puckaway, and Buffalo Lake. These lakes are impacted by a variety of pollutants, including atmospheric mercury, excessive nonpoint phosphorous, and PCBs in sediments. The complete list of 303(d) impaired waters and criteria can be viewed at the Wisconsin DNR's impaired waters web page (WDNR 2010b).

Ten streams are similarly impacted by PCBs that contaminate fish tissue, excessive sediment input, excessive nutrients, elevated water temperature, or impaired habitat values. These streams are the Fox River, Wisconsin River, Wendt Creek, Halfway Prairie Creek, Carpenter Creek, Hill Creek, Silver Creek, Roy Creek, and two unnamed creeks. Contaminated sediments from past discharges (especially PCBs in Silver Creek) and heavy metals pose risks to aquatic life (and in some cases to humans). Industrial and municipal point sources from industries in Ripon continue to impact water quality in Big Green Lake.

Agricultural and urban land uses create nonpoint source and some point source pollution as well as stream habitat degradation from ***flashy*** storm flows. Erosion, sediment build-up, and dams impact stream habitats. Animal waste and soil erosion problems are evident along reaches of the Pine River, Willow Creek, and in parts of the Waupaca River watershed. Urban nonpoint runoff, sedimentation, excess nutrient loads, and heavy recreational boating use all impact water quality and shoreline habitats. Excessive phosphorous from industrial cooling water and other sources create wide fluctuations in oxygen concentrations to the detriment of fish and other aquatic life. This situation produces heavy algal blooms and often helps create ideal conditions for carp and certain aquatic worms, leeches, and snails. General watershed water quality summaries are included in Appendix 9.A.

Biotic Environment

Vegetation and Land Cover

Historical Vegetation

Several sources were used to characterize the ***historical vegetation*** of the Central Sand Hills Ecological Landscape, relying heavily on data from the federal General Land Office's public land survey (PLS), conducted in Wisconsin between 1832 and 1866 (Schulte and Mladenoff 2001). PLS data are useful for providing estimates of forest composition and tree species dominance for large areas (Manies and Mladenoff 2000). Finley's map of historical land cover based on his interpretation of PLS data was also consulted (Finley 1976). Additional inferences about vegetative cover were sometimes drawn from information on land capability, climate, disturbance regimes, the activities of native peoples, and from various descriptive narratives. More information about these data sources is available in Appendix C, "Data Sources Used in the Book," in Part 3, "Supporting Materials."

According to Finley's map and data interpretation (Finley 1976), in the mid-1800s, the Central Sand Hills Ecological Landscape was dominated by either oak forest or oak opening, with interspersed wetlands (mostly marsh and sedge meadow) (Figure 9.2). Only 8,700 acres of the ecological landscape was covered by mesic upland forest, the least amount of this forest type in any ecological landscape (also see the map

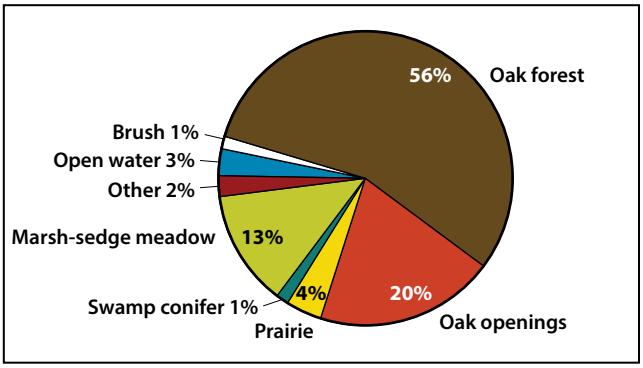


Figure 9.2. *Vegetation of the Central Sand Hills Ecological Landscape during the mid-1800s as interpreted by Finley (1976) from federal General Land Office public land survey information.*

"Vegetation of Wisconsin in the Mid-1800s" in Appendix G, "Statewide Maps," in Part 3, "Supporting Materials").

PLS information has been converted to a database format, and relative importance values (RIV) for tree species were calculated based on the average of tree species density and ***basal area*** (He et al. 2000). This analysis indicates that oak species were the dominant trees in the Central Sand Hills (94.1% of the RIV). Black oak (*Quercus velutina*) (36.7%), white oak (*Quercus alba*) (29.1%), and bur oak (*Quercus macrocarpa*) (25.4%) had the highest RIVs of all the tree species found in this ecological landscape with no other tree species having RIVs higher than 5%. See the map "Vegetation of the Central Sand Hills Ecological Landscape in the Mid-1800s" in Appendix 9.K at the end of this chapter.

Current Vegetation

There are several data sets available to help assess current vegetation on a broad scale in Wisconsin. Each was developed for different purposes and has its own strengths and limitations in describing vegetation. For the most part, WISCLAND (Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data), the Wisconsin Wetlands Inventory (WWI), the U.S. Forest Service's Forest Inventory and Analysis (FIA), and the National Land Cover Database (NLCD) were used. Results among these data sets often differ as they are the products of different methodologies for classifying land cover, and each data set was compiled based on sampling or imagery collected in different years, sometimes at different seasons, and at different scales. In general, information was cited from the data sets deemed most appropriate for the specific factor being discussed. Information on data source methodologies, strengths, and limitations is provided in Appendix C, "Data Sources Used in the Book," in Part 3, "Supporting Materials."

The Central Sand Hills Ecological Landscape is approximately 1,389,000 acres in size, of which approximately 33% was forested and 34% was in agricultural use in 1992 (WDNR 1993). WISCLAND land use/land cover data from 1992 indicates that 19% of the ecological landscape was classified as grassland (though almost none of this is native prairie), which is the second highest percentage of grassland of all of the ecological landscapes, second only to the Western Prairie Ecological Landscape (Figure 9.3).

The Wisconsin Wetlands Inventory offers a more specific assessment of wetlands than is available with WISCLAND data but is limited to those areas identified from aerial photography as wetlands. According to the Wisconsin Wetlands Inventory, wetlands occupy a relatively large portion of the Central Sand Hills, comprising 18.3%, (approximately 254,000 acres) of this ecological landscape's vegetation (WDNR 2010c). Forested wetlands make up over 107,000 acres of the ecological landscape, making these the most abundant wetlands in the Central Sand Hills. Wet meadows (including emergent marsh and sedge meadow) occupy approximately 81,000 acres. Shrub/scrub wetlands occur across approximately 56,000 acres.

Additional information on wetlands and wetland flora may be found in the "Natural Communities" and "Flora" sections of this chapter, and in Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin," in Part 1 of this publication.

Forest Inventory and Analysis (FIA) data from 2004 is a U.S. Forest Service program that compiles point samples of forested lands to assess the timber resources of the country (USFS 2004). It contains more information on forest types and species compositions that can be generalized across the ecological landscape and offers more specific information about forested lands than WISCLAND. Because FIA data are derived from on the ground sampling as opposed to analysis of air photos or satellite imagery, the numbers may offer a different interpretation of forests than WISCLAND. According to FIA data summarized in 2004, approximately 66% of land area in the Central Sand Hills Ecological Landscape was nonforested and about 34% was forested at that time. The predominant forest ***cover type*** group is oak-hickory (47.0% of the forested area). Each of the other forest types individually occupies less than 10% of the forested area (Figure 9.4).

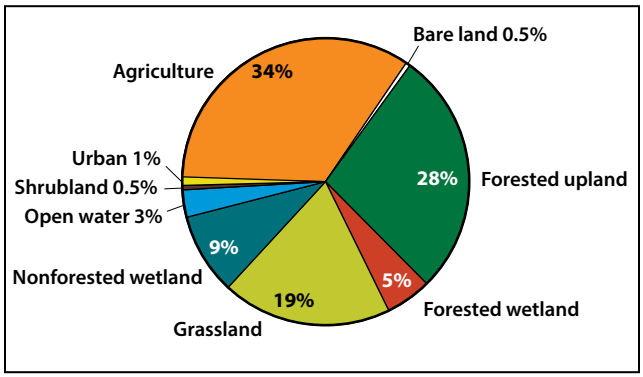


Figure 9.3. *WISCLAND land use/land cover data showing categories of land use classified from 1992 LANDSAT satellite imagery for the Central Sand Hills Ecological Landscape (WDNR 1993).*

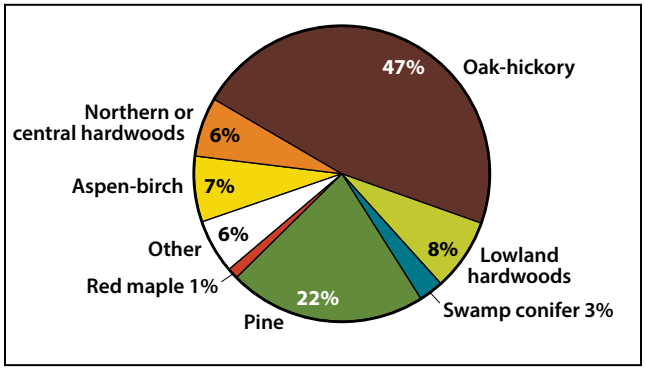


Figure 9.4. *Forest Inventory and Analysis data (USFS 2004) showing forest type as a percentage of forested land area (greater than 17% crown cover) for the Central Sand Hills Ecological Landscape. See Appendix C, "Data Sources Used in the Book," in Part 3, "Supporting Materials," for more information about the FIA data.*

Changes in Vegetation over Time

Fire, the dynamic force responsible for shaping and maintaining much of the forest, savanna, prairie, and some wetland vegetation in the Central Sand Hills, has been all but eliminated from the present ecological landscape. Dams, dikes, ditches, and groundwater withdrawals have altered the abundance, composition, and structure of many wetland communities as well as the hydrologic regimes that supported them. Grazing, along with increased sediment and nutrient loads, has reduced or eliminated many native herbs and favored the dominance and spread of invasive species such as reed canary grass (*Phalaris arundinacea*).

The overall amount of forest and other communities that were dominated by trees has decreased significantly in the Central Sand Hills. Savannas are now virtually absent, though restoration may be feasible in some areas. Historically, forest, woodland, and savanna communities comprised over 75% of the vegetative cover of the Central Sand Hills (Finley 1976). In 2004 the figure was 34% (USFS 2004), almost all of which was forest, based on the amount of canopy cover and tree density. The losses are due to agricultural conversion, residential development, and in the case of savannas, succession in the absence of periodic fire. Over time, the nature of the forests will also change as the fire-adapted oaks are replaced by species such as eastern white pine or red maple. On sandy soils, many prairies, savannas, woodlands, and marginal agricultural lands have been planted to red pine (*Pinus resinosa*) monotypes.

Wetlands have been altered by hydrologic changes due to dam, ditch, and dike construction; grazing; and runoff laden with excessive amounts of nutrients and sediments. Aquatic ecosystems have suffered from eutrophication, intensive shoreline development, sediment deposition, and the activities of introduced, and now invasive, species such as common carp and Eurasian water-milfoil. In many areas, native wetland species have been replaced by aggressive, nonnative plants such as reed canary grass, common reed (*Phragmites australis*), and glossy buckthorn (*Rhamnus frangula*). Drainage of wetlands has occurred in many areas. At some locations, such as those formerly occupied by tamarack swamps, the drained and cleared peatlands were converted to muck farms. Active fire suppression and prevention have exacerbated some of these problems, especially in sedge meadows, fens, and low prairies, where woody growth is now outcompeting light-demanding herbs, and perhaps in tamarack swamps, where succession to hardwood trees and tall shrubs creates dense shade, playing a role in prevention of tamarack from regenerating and maintaining dominance.

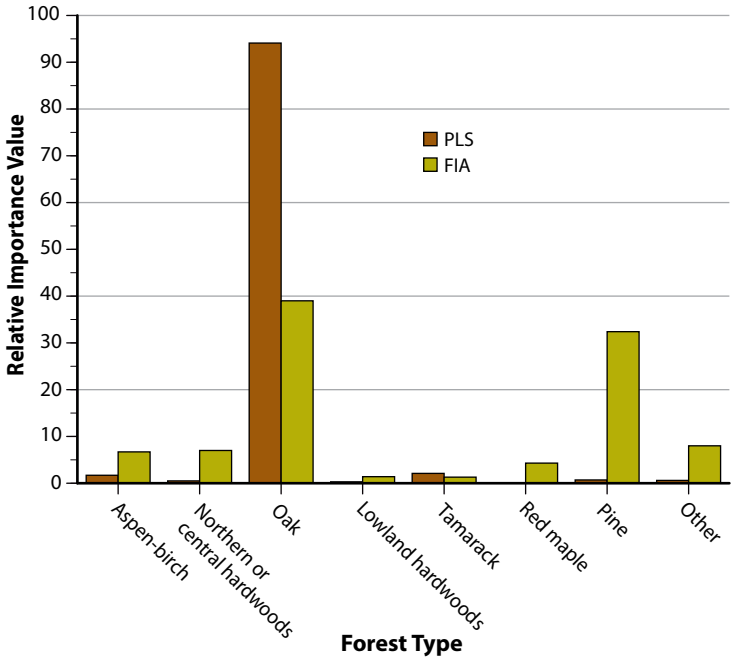


Figure 9.5. *Comparison of tree species' relative importance value (average of relative dominance and relative density) for the Central Sand Hills Ecological Landscape during the mid-1800s, when federal public land survey (PLS) data were collected, with 2004 estimates from Forest Inventory and Analysis (FIA) data (USFS 2004). Each bar represents the proportion of that forest type in the data set (totals equal 100). Trees of less than 6-inch diameter were excluded from the FIA data set to make it more comparable with PLS data. See Appendix C, "Data Sources Used in the Book," in Part 3, "Supporting Materials," for more information about the PLS and FIA data.*

The purpose of examining historical conditions is to identify ecosystem factors that formerly sustained species and communities now altered in number, size, or extent or that have been changed functionally (for example, by constructing dams, or suppressing fires). Although most of the historical vegetation data are limited to a specific period in the mid-1800s, they provide valuable insights into Wisconsin's ecological capabilities, especially prior to settlement of the state by people of European descent. Maintaining or restoring some lands to more closely resemble historical systems and including some structural or compositional components of the historical landscape within actively managed lands can help conserve important elements of biological diversity, especially those at risk of disappearing and potentially affecting the behavior and abundance of additional native plants and animals. We do not suggest or mean to imply that entire ecological landscapes should be restored to historical conditions as this is neither possible nor necessarily desirable within the context of providing for human needs and desires. Information on the methodology, strengths, and limitations of the vegetation change data is provided in Appendix C, "Data Sources Used in the Book" in Part 3, "Supporting Materials."

Current forest vegetation (based on FIA) is primarily oak species (39.0% of RIV) and pine species (34.2% of RIV) (Figure 9.5). Pine has increased dramatically from 0.7% to 34.2% of RIV. Most notably, red pine has increased one

hundred fold from 0.24% to 24.1% of RIV. Oak species have decreased from 94.1% to 39% of RIV. Within the oak species, black oak (from 36.7% of RIV to 13.1%), bur oak (from 25.3% of RIV to 2.4%), and white oak (from 29.1% of RIV to 10.9%) have decreased, while northern red oak (*Quercus rubra*) has increased (from 0.3% to 6.0% of RIV).

Natural Communities

This section summarizes the abundance and importance of major physiognomic (structural) natural community groups in this ecological landscape. Some of the exceptional opportunities, needs, and actions associated with these groups or with some of the individual natural communities are discussed briefly. For details on the composition, structure, and distribution of the specific natural communities found in the Central Sand Hills, see Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin." Information on invasive species can be found in the "Natural and Human Disturbances" section of this chapter.

Forests. Upland forests are virtually all second-growth, and though forest communities are fairly extensive here overall, large patches of contiguous forest are uncommon due to habitat fragmentation, land ownership patterns, and prevalent land uses. Site conditions on the uplands are mostly dry, with some dry-mesic sites. Oak forests were historically widespread and abundant, especially those dominated by species such as bur, black, and/or white oaks, which are often associated with drier sites. At some locations, the oaks were, and still are, mixed with pines. Eastern white pine (*Pinus strobus*) and red pine were occasionally prevalent canopy species, and jack pine (*Pinus banksiana*) occurred in some areas. Red pine plantations are now common, especially where drought-prone infertile lands were abandoned following attempts to use them for agricultural purposes. The potential for oak management is generally high, particularly on the dry sites, but this does not always include commercially valuable species such as northern red oak.

Many areas of southern Wisconsin that were formerly dominated by oaks are succeeding to species with higher shade tolerance, due in large part to the absence of fire. Selective extraction of the oaks can accelerate these successional processes. One common forest type, referred to as "central hardwoods," can contain a wide variety of tree species, including maples (*Acer* spp.), hickories (*Carya* spp.), elms (*Ulmus* spp.), black cherry (*Prunus serotina*), and several others. This type was not common historically and is a result of past and current land uses and management methods. Some central hardwood sites might provide opportunities for oak restoration, although this is often very difficult on the more mesic sites and requires resource and time commitments that would be prohibitive for many landowners. On some sites, central hardwood species might provide a component of diversity to places that would otherwise be dominated by red maple or plantation-grown red pine.

*Black oak and white oak are the canopy dominants in this Southern Dry Forest. This community is still common in the Central Sand Hills Ecological Landscape but many stands have been altered by grazing, **high-grading,** or conversion to pine plantations. Photo by Andy Clark, Wisconsin DNR.*

Some forests in the sandy portions of central Wisconsin support mixtures of southern and northern species. This stand near the Pine River in Waushara County features a canopy of northern red, white, and black oaks, and eastern white pine. Photo by Andy Clark, Wisconsin DNR.

Older, intact forests dominated by large red pine and eastern white pine are now rare in central Wisconsin. New Hope Pines State Natural Area, Portage County. Photo by Thomas Meyer, Wisconsin DNR.

Important lowland forest communities include tamarack-dominated conifer swamps and riparian forests composed of bottomland hardwoods. In the Central Sand Hills, nearly all of the bottomland hardwoods are associated with the floodplains of the larger rivers. A large insular peatland (Dewey Marsh) in north-central Portage County represents one of Wisconsin's southernmost locations for black spruce. The extensive levee system near Portage has significantly confined the floodplain of the Wisconsin River, isolating thousands of acres of wetlands that were formerly directly connected to the river. There are many marshes, sedge meadows, shrub-carrs, and early successional forests of aspens (*Populus* spp.), river birch (*Betula nigra*), and/or black oak behind the Portage levee system, especially at the Pine Island Wildlife Area. Some wetlands remain in better shape behind the levees, at least temporarily, because they do not receive the flush of reed canary grass seed that sometimes occurs when the river floods (M. Mossman, Wisconsin DNR, personal communication). The large dam at Prairie du Sac has inundated large areas that formerly supported floodplain forest.

Savannas. Examples of two savanna communities may be found here. Oak Barrens are most frequent on nutrient poor, droughty sands where the topography is level or relatively subdued and severe wildfires were historically common and frequent. Black oak was the dominant tree, often persisting in burned areas as shrub-like "grubs." These ***oak grubs*** were often the source of the trees that quickly grew up and formed densely stocked forests once fire suppression had become effective early in the 20th century. In the Oak Openings, bur and white oaks tend to be the most important canopy species, though black oak is often present. Frequent fires of low intensity are thought to have maintained the Oak Openings, which in some areas were characterized by very large trees with widely spreading crowns and limbs. Oak Openings and Oak Barrens were both historically common in the Central Sand Hills, grading into dry to dry-mesic prairies on the windward side where the topography and the absence of waterbodies and wetlands allowed fires to run unimpeded. Where physical barriers prevented fires from running unchecked, forests of oak or of oaks mixed with pines were likely to develop. Mixed barrens of oaks and pines occurred in some areas that burned more frequently or with higher intensity.

The widespread implementation of fire suppression policies early in the 20th century terminated the wildfires that had shaped and maintained much of this ecological landscape's native vegetation. In many places, the prairies and savannas succeeded quickly to oak forests. In grazed savannas, the characteristic structure of widely scattered open-grown trees was sometimes maintained, but the ground layer of fire-adapted understory plants was often replaced by weedy generalists or nonnative plants better suited than the native species to thriving under a regime of continuous grazing pressure.

Though rare, some of the bedrock exposures in the Central Sand Hills, such as the rhyolite exposures east of Neshkoro, support very unusual communities that structurally resemble savannas or woodlands. Oaks are usually dominant, especially on the more xeric southern and western exposures, but shagbark hickory (*Carya ovata*) and, in a few areas, ashes may also be present. The understories often contain native prairie and savanna associates but also support species that are bedrock habitat specialists, including nonvascular plants.

Shrub Communities. Alder Thicket and Shrub-carr are both common along the borders of smaller streams, on some lakeshores, and on the margins of some wetlands. Shrub-carr, because of fire suppression and wetland drainage, may have expanded in some areas that supported sedge meadow, wet prairie, and fen communities prior to Euro-American settlement. Tall wetland shrubs are now the dominant cover in some former tamarack swamps where tamarack die-off has become increasingly common in recent decades. In some of these stands, tamarack regeneration is now minimal or altogether absent because of these increases in abundance of deciduous woody plants.

Herbaceous Communities. Prairies were moderately common on sites that burned with such frequency and severity that woody plants were suppressed and the amount of woody cover was negligible. Many of the remnants persisting today are found within transportation or utility rights-of-way or

*Hydrologically intact Northern Sedge Meadow, with wire-leaved graminoids such woolly sedge (*Carex lasiocarpa*) and twig-rush (*Cladium mariscoides*) among the dominant species. Many rare plant and animal species have been documented at this Marquette County wetland. Photo by Eric Epstein, Wisconsin DNR.*

Bedrock Glade community on rhyolite bluff. Stunted oaks, prairie herbs, rock specialists. Pine Bluff, Green Lake County. Photo by Eric Epstein, Wisconsin DNR.

on sites that are too infertile, stony, or steep to be used intensively for agricultural purposes.

Herbaceous wetlands include Wet and Wet-mesic Prairies, Calcareous Fen, Southern Sedge Meadow, Northern Sedge Meadow, and several types of marsh. The abundance of many of these native wetland communities has been greatly reduced due to wetland drainage and the effects of fire suppression. Along with these functional disruptions, grazing by domestic livestock has been widespread and led to the degradation of many sedge meadows, prairies, and fens. This has resulted in tremendous increases in aggressive nonnative plants, such as reed canary grass, at the expense of the native flora.

Marshes are still common and extensive in some of the lake basins and along the margins of some of the low gradient warmwater rivers and streams.

Bedrock Communities. Bedrock exposures are rare here but include bluffs and mounds composed of rhyolite or sandstone. Natural communities associated with these features include cliffs, glades, and ***talus slopes***. The Precambrian "rhyolite glades" are characterized by sparse vegetation that resembles a savanna of stunted oaks and hickories, with prairie plants and bedrock specialists occupying the sunnier openings. Site conditions are extreme, and the trees are often stunted and gnarly, especially on the hot southern or western exposures. The strong bedrock influence favors the growth of habitat specialists or species that fare poorly under a dense canopy of shrubs and trees. For species able to tolerate the harsh substrate conditions, the glades may serve as ***refugia*** for species that may have been more widespread in the past. For example, some plants formerly associated with the oak savannas, which were historically widespread and abundant here but are now almost gone, may find similar environmental conditions of partial or filtered shade in the glades. Forests of oak, pine, or mixtures of oak and pine may be present, sometimes occurring on different (e.g., cooler, somewhat moister) aspects of the same bluff. The Ordovician St. Peter sandstone rarely outcrops in this ecological landscape but has formed spectacular cliffs over 30 meters high at Gibraltar Rock in southwestern Columbia County.

Rare plants have been documented on a number of these bedrock features; more detailed surveys of the nonvascular flora and invertebrates are needed to better document the population sizes, distributions, and habitat associations of these taxa and to clarify their conservation significance.

Aquatic Communities. See the "Hydrology" section of this chapter and Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin."

Forest Habitat Types

Within the Central Sand Hills Ecological Landscape, site variability is high. Although all major southern habitat type groups occur, only four groups are common: dry-mesic, dry, wet-mesic to wet, and dry-mesic to mesic (Table 9.1).

Dry-mesic sites are typically associated with sandy loam soils that are well drained and nutrient medium. Most stands are dominated by some mixture of white, northern red, black, and northern pin (*Quercus ellipsoidalis*) oak, eastern white and/or red pine, red maple (*Acer rubrum*), and aspen. Potential late-successional dominants are red maple with eastern white pine, white oak, and northern red oak.

Dry sites are typically associated with sandy soils that are excessively to somewhat excessively drained and nutrient poor to medium. Currently, oaks (northern pin, black, northern red, white) and pines (jack, red, eastern white) are the dominant trees; aspen and red maple also are common. In the absence of disturbance, potential late-successional dominants are eastern white pine and red maple, accompanied by white oak and northern red oak.

Table 9.1. *Forest habitat type groups and forest habitat types of the Central Sand Hills Ecological Landscape (CSH EL).*

Southern forest habitat type groups common within the CSH EL[b]	Southern forest habitat types[a] common within the CSH EL[b]	Southern forest habitat types minor within the CSH EL[b]
Dry-mesic (DM)	ArDe	
Dry (D)	PVG	PEu
Wet-mesic to wet (WM-W)	Forest Lowland (habitat types not defined)	
Dry-mesic to mesic (DM-M) (includes phases)		ATiFrCi ATiFrVb(Cr) ATiFrVb
Southern forest habitat type groups minor within the CSH EL		
Mesic (M) (includes phases)		ATiFrCa(O)
Mesic to wet-mesic (M-WM)		Undefined wet-mesic (habitat types not defined)

Source: Kotar and Burger (1996).
[a]Forest habitat types are explained in Appendix 9.B ("Forest Habitat Types in the Central Sand Hills Ecological Landscape") at the end of this chapter.
[b]Groups listed in order from most to least common:
Common occurrence is an estimated 10–50% of forested land area.
Minor occurrence is an estimated 1–9% of forested land area.
Present – Other habitat types can occur locally, but each represents < 1% of the forested land area of the ecological landscape.

Wet-mesic to wet forested lowlands typically occur on poorly drained, nutrient poor to medium peat, and muck soils. Most stands are dominated by swamp conifers but may include jack pine, eastern white pine, red maple, white birch (*Betula papyrifera*), and aspen. Some sites with richer muck or mineral soils do occur and may be dominated by either swamp conifers or hardwoods.

Dry-mesic to mesic sites are typically associated with loamy soils that are well to moderately well drained and nutrient rich. The most common overstory dominants are white oak and northern red oak. Common associates are black cherry, shagbark hickory, American basswood (*Tilia americana*), white ash (*Fraxinus americana*), sugar maple (*Acer saccharum*), red maple, elms, black oak, and aspen. Potential late-successional dominants are sugar maple with American basswood and white ash.

Flora

The rare plant database of the Wisconsin Natural Heritage Inventory includes 61 vascular plant species that have been documented in the Central Sand Hills Ecological Landscape (WDNR 2009). Of these 61 plants, 9 are listed as Wisconsin Endangered, 14 are Wisconsin Threatened, and 38 are Wisconsin Special Concern.

Two species listed as endangered by the State of Wisconsin also have legal protection at the federal level: prairie bush-clover (*Lespedeza leptostachya*) and Fassett's locoweed (*Oxytropis campestris* var. *chartacea*), both listed as U.S. Threatened by the U.S. Fish and Wildlife Service. Federal recovery plans were prepared for both Fassett's locoweed (USFWS 1991) and prairie bush-clover (USFWS 1988). Six of the world's eight

Fassett's locoweed (U.S. Threatened, Wisconsin Endangered) is a globally rare plant known only from the shores of a few seepage lakes in the sandy regions of central and northwestern Wisconsin. Photo by Thomas Meyer, Wisconsin DNR.

known populations of Fassett's locoweed, a varietal ***endemic***, occur in the Central Sand Hills. This highly specialized plant dwells on the sandy or gravelly shores of groundwater fed seepage lakes here and in one other ecological landscape (the Northwest Sands). Four of the rare plant species documented in the Central Sand Hills have been found in no other Wisconsin ecological landscape: bushy aster (*Aster dumosus*), brook grass (*Catabrosa aquatica*), dwarf umbrella-sedge (*Fuirena pumila*), and long-beaked bald-rush (*Psilocarya scirpoides*). The long-beaked bald-rush is represented here by six known populations; the other three are known only from single populations. Brook grass is known only from undisturbed spring margins; the other species are associated with the very rare Coastal Plain Marsh community or habitats that are similar in structure and function.

Rare plants not mentioned previously that are represented in the Central Sand Hills Ecological Landscape by 50% or more of their Wisconsin populations include yellow wild-indigo (*Baptisia tinctoria*), Flodman's thistle (*Cirsium flodmanii*), and slender bulrush (*Schoenoplectus heterochaetus,* listed as *Scirpus heterochaetus* on the Wisconsin Natural Heritage Working List; WDNR 2009). Flodman's thistle is a problematic species as it is treated as an adventive in Wetter et al. (2001). However, the species is represented in the Central Sand Hills by at least one population that is thought by some botanists to be of natural origin (C. Anderson, Wisconsin DNR, personal communication).

Plants found here that are globally rare are Hill's thistle (*Cirsium hillii*), prairie bush-clover, and bog bluegrass (*Poa paludigena*) (WDNR 2009). Shadowy goldenrod (*Solidago sciaphila*) and prairie fame-flower (*Talinum rugospermum*) are also thought to be facing significant problems, often due to habitat loss or alteration, in at least parts of their limited geographic ranges.

For additional information on the rare plants tracked by the Wisconsin Natural Heritage Inventory, see Appendix 9.C and the Wisconsin DNR website for the current Wisconsin Natural Heritage Working List (WDNR 2009).

Populations of rare plants have been documented in virtually all of this ecological landscape's native vegetation types and also in association with certain geological and aquatic features. All native communities (forests, savannas, shrub swamps, prairies, sedge meadows, fens, and communities on primary substrates such as bedrock, bare sand, or mud) have some potential to support rare plants, as do geological, aquatic, and cultural features such as sandblows, borrow pits, and surrogate grasslands.

Intact stands of peaty, alkaline wetland communities such as Calcareous Fen, Southern Tamarack Swamp, and some sedge meadows have high potential to support rare ***calciphilic plants***. The springs and seepages associated with and found within these communities may also support rare plants.

Prairie remnants may harbor diverse concentrations of native grasses and forbs, many of which do not persist in highly disturbed or altered grassland habitats. Rock outcroppings (such as cliffs, glades, and talus slopes), lakeshores, and spring seeps are also known to provide habitat for many sensitive plant species.

Coastal Plain Marsh is a rare natural community that is known from only a few ecological landscapes. The many rare plants associated with this community include a group known

Significant Flora in the Central Sand Hills Ecological Landscape

- Groundwater-fed alkaline wetlands support numerous rare plant species.
- The sandy or gravelly shorelines of seepage lakes that exhibit naturally fluctuating water levels support several rare plant species, including a Wisconsin endemic.
- Rare wetland communities such as Coastal Plain Marsh are of high value to unusual plants, including many ***disjunct species***.
- Fire-adapted natural communities such as prairies, sedge meadows, fens, savannas, woodlands, and forests all support rare or otherwise sensitive plant species.
- Floodplain corridors along the larger rivers support habitat specialists. In the Central Sand Hills, such habitats have been poorly surveyed.
- Bedrock exposures are infrequent but disproportionately important to highly specialized plants.
- Surveys of nonvascular plants are needed, especially in peatland, beach, and bedrock habitats.
- Range-wide surveys are needed to identify and better document the composition and status of rare natural communities such as Coastal Plain Marsh, Calcareous Fen, and Inland Beach.

Alkaline pools are important micro-habitats that support some of the specialized plants and animals found within Calcareous Fens. Bass Lake Fen State Natural Area, Waushara County. Photo by Eric Epstein, Wisconsin DNR.

*Small white lady's-slipper (*Cypripedium candidum*) is a rare orchid of Calcareous Fens and other alkaline grasslands in southern Wisconsin. Photo by Drew Feldkirchner, Wisconsin DNR.*

*The Wisconsin Threatened brittle prickly pear (*Opuntia fragilis*) is a rare habitat specialist known from several Bedrock Glades in the Central Sand Hills. Photo by Wisconsin DNR staff.*

collectively as Atlantic coastal plain disjuncts (see Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin"). Major threats to the rare plants in this ecological landscape include hydrological disruption (changes to natural flood regimes and drainage patterns as well as diminished water quality and quantity); the negative impacts of continued fire suppression on species adapted to prairie, savanna and woodland conditions; small size and isolation of the habitats upon which many rare species depend; and the spread of invasive plants and animals that can disrupt ecosystem structure, composition and function.

Fauna

Changes in Wildlife over Time

Many wildlife populations have changed dramatically since humans arrived on the landscape, but these changes were not well documented before the mid-1800s. This section discusses only those wildlife species documented in the Central Sand Hills Ecological Landscape. Of those, this review is limited to species that were known or thought to be especially important here in comparison to other ecological landscapes. For a more complete review of historical wildlife in the state, see a collection of articles written by A.W. Schorger, compiled into the volume *Wildlife in Early Wisconsin: A Collection of Works by A.W. Schorger* (Brockman and Dow 1982).

The Central Sand Hills was important historically for a number of wildlife species, especially those using wetlands (particularly sedge meadows), oak openings, and prairies as well as oak and oak-pine forests. This ecological landscape was particularly important for the Passenger Pigeon (*Ectopistes migratorius*), Sandhill Crane, Sharp-tailed Grouse (*Tympanuchus phasianellus*), and Greater Prairie-Chicken (*Tympanuchus cupido*). Wildlife populations changed following logging of the forests during the state's ***Cutover***, later Euro-American settlement, draining of the wetlands and plowing of the prairies in the late 19th and early 20th century, and a long history of wildfire prevention and control.

Although the distribution of the Passenger Pigeon has been described as covering the eastern half of North America, its nesting was limited by the presence and abundance of mast (primarily beech nuts and acorns). Schorger (1946) reported from newspaper accounts and interviews that Passenger Pigeons nested by the millions in Wisconsin. With a large presence of oak forest and oak savanna, this ecological landscape was an important nesting area for Passenger Pigeons during years of high mast production. There are many references to Passenger Pigeons in the area around Kilbourn (Wisconsin Dells). In 1871 a large nesting took place in the center of the state. In 1877 a small nesting took place in Marquette County (Schorger 1939). A Mr. Reynolds told Schorger that prior to 1882 "millions and millions of birds left the nestings north of Kilbourn and that he was never satisfied as to where they went" (Schorger 1946). Passenger Pigeons were shot and trapped during the nesting season and squabs taken from nests and shipped to markets in Milwaukee, Chicago, and cities on the east coast by the trainload (Schorger 1939). Since the Passenger Pigeon was thought to only lay one egg each year, only nested in communal roosts, and was dependent on abundant mast for nest production, the heavy kill of Passenger Pigeons led to its extinction. After 1882 a noticeable decline of the Passenger Pigeon was noted in Wisconsin. An attempted nesting occurred near Wautoma in 1887 but failed because many of the nesting birds were shot or disturbed (Schorger 1946). It was the last documented attempt at mass nesting in the state. In 1890 several thousand pigeons appeared near Briggsville, Wautoma, and several other places in the state. Populations continued to decline, with few sightings in Wisconsin during

the late 1890s. The year 1899 is considered the end of the wild Passenger Pigeon in Wisconsin. The last known Passenger Pigeon died in 1914 at the Cincinnati Zoo.

Prior to 1850, the Sandhill Crane was a common breeding bird in the marshes of Upper Great Lakes states. It declined due to shooting for meat, habitat destruction, and human disturbance (Schorger 1942). It continued to decline until the late 1930s when it was believed only 12 pairs were left nesting in the state (Hamerstrom 1938). Isolated nesting areas at that time occurred in Marquette and Green Lake counties in the Central Sand Hills Ecological Landscape as well as in the Central Sand Plains and Northwest Sands ecological landscapes. Sandhill Cranes have since recovered and are now found throughout the state in favorable nesting habitat. The Central Sand Hills is still an important nesting area for this species.

The Sharp-tailed Grouse was considered widely distributed in the state in open and brushy habitats before widespread Euro-American settlement and was likely common in this ecological landscape, primarily occupying prairies and oak openings (Schorger 1943). Wildfire suppression and prevention allowed prairies and oak openings to become dense forests, or these open areas were converted to agricultural production, both factors causing populations of Sharp-tailed Grouse to decline. Today there are no Sharp-tailed Grouse here.

The Greater Prairie-Chicken was found throughout southern Wisconsin before Euro-settlement, although the Sharp-tailed Grouse may have been more abundant (Schorger 1943). The Greater Prairie-Chicken was found in this ecological landscape, but as with Sharp-tailed Grouse, in the absence of fire prairies and oak openings reverted to forests or were converted to agriculture, and populations declined (see the "Fauna" section in Chapter 10, "Central Sand Plains Ecological Landscape," for a more detailed discussion of the Greater Prairie-Chicken in Wisconsin). Today there are no Greater Prairie-Chickens in this ecological landscape.

The eastern massasauga (*Sistrurus catenatus catenatus*) was historically abundant in the Central Sand Hills while the timber rattlesnake (*Crotalus horridus*) reached the eastern edge of its range here (Schorger 1967; Figure 9.6). Timber rattlesnakes have never been found east of Madison. Eastern massasaugas were found in marshy areas, lowland prairies, and along streams and have been found throughout southern and central Wisconsin. Vogt (1981) noted that "thousands of massasaugas were killed near Portage in 1849" and that "they were still common south of Portage in the 1950s." Populations of both rattlesnake species have been dramatically reduced by land use changes and continued persecution. The eastern massasauga is more sensitive to habitat changes, is now listed as a Wisconsin Endangered species, and is a formal candidate for federal listing. The eastern massasauga has not been observed in the Central Sand Hills Ecological Landscape since 1977 (Appendix 9.C).

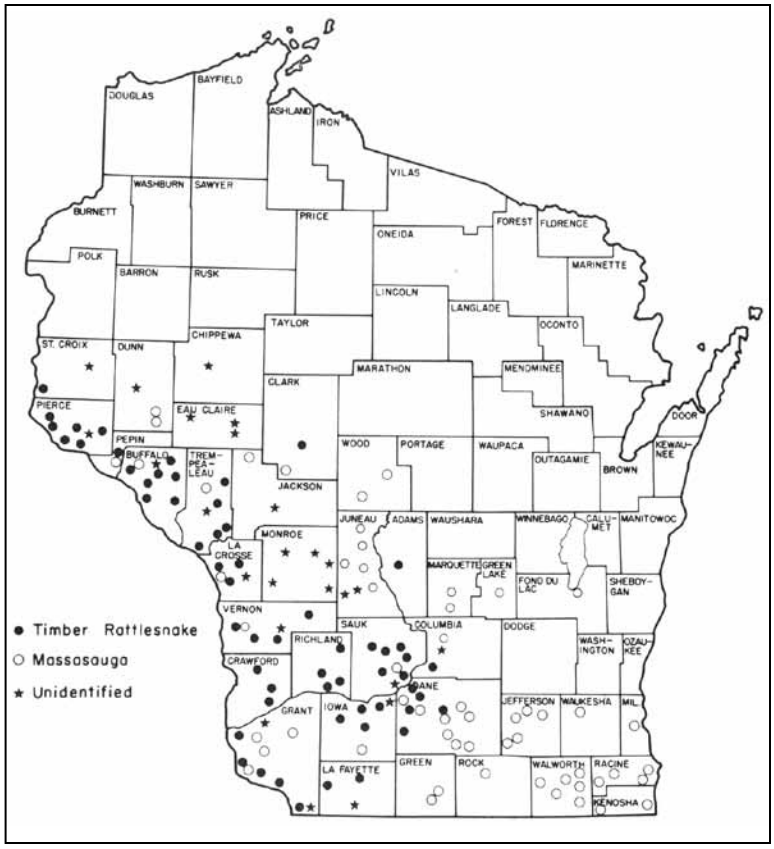


Figure 9.6. *Historical timber and massasauga rattlesnake range in Wisconsin. Figure reproduced from Schorger (1967) by permission of Wisconsin Academy of Sciences, Arts and Letters.*

Significant Wildlife

Wildlife are considered significant for an ecological landscape if (1) the ecological landscape is considered important for maintaining the species in the state and/or (2) the species provides important recreational, social, and economic benefits to the state. To ensure that all native species are maintained in the state, "significant wildlife" includes both common species and species that are considered "rare" (in this publication "rare" includes species listed as endangered or threatened by either Wisconsin or the federal government or species that are listed as "special concern" by the State of Wisconsin). Four categories of species are discussed: rare species, Species of Greatest Conservation Need (SGCN), responsibility species, and socially important species (see definitions in text box). As the conservation and maintenance of wildlife communities (e.g., grassland birds) are the most efficient and cost effective way to manage and benefit a majority of species, we discuss management of different wildlife habitats in which significant fauna occur.

Categories of Significant Wildlife

- **Rare species** are those that appear on the Wisconsin Natural Heritage Working List as Wisconsin or U.S. Endangered, Threatened, or Special Concern.
- **Species of Greatest Conservation Need** are described and listed in the Wisconsin Wildlife Action Plan (WDNR 2005) as those native wildlife species that have low or declining populations, are "indicative of the diversity and health of wildlife" of the state, and need proactive attention in order to avoid additional formal protection.
- **Responsibility species** are both common and rare species whose populations are dependent on Wisconsin for their continued existence (e.g., a relatively high percentage of the global population occurs in Wisconsin). For such a species to be designated a "responsibility species," a relatively high percentage of the state population needs to occur there, or good opportunities for effective population protection and habitat management for that species occur in the ecological landscape. Also included here are species for which an ecological landscape holds the state's largest populations, which may be critical for that species' continued existence in Wisconsin even though Wisconsin may not be important for its global survival.
- **Socially important species** are those that provide important recreational, social, or economic benefits to the state for activities such as fishing, hunting, trapping, and wildlife watching.

Male Karner blue butterfly (U.S. Endangered, Wisconsin Special Concern), nectaring on native flowering spurge. Photo by Gregor Schuurman, Wisconsin DNR.

Rare Species. As of November 2009 (WDNR 2009), the Wisconsin Natural Heritage Working List documented 115 rare species within this ecological landscape, including 4 mammals, 28 birds, 16 herptiles, 17 fish, and 50 invertebrates (see Appendix 9.D). These include one U.S. Endangered species, two species being considered for federal listing, 16 Wisconsin Endangered species, 23 Wisconsin Threatened species, and 76 Wisconsin Special Concern species (one federally listed species is also a Wisconsin Special Concern species). See Appendix 9.C for a comprehensive list of the rare animals known to exist in the Central Sand Hills Ecological Landscape.

Federally Listed Species: The Karner blue butterfly (*Lycaeides melissa samuelis*) is listed as U.S. Endangered and occurs throughout the Central Sand Hills Ecological Landscape. It is also listed as Wisconsin Special Concern (WDNR 2009). The Karner blue butterfly is managed under a habitat conservation plan approved by the U.S. Fish and Wildlife Service approved in 1999 and revised in 2009. The gray wolf (*Canis lupus*) was removed from the federal threatened species list in January 2012, granting management authority to the State of Wisconsin. The Wisconsin state legislature passed a law in April 2012 authorizing hunting and trapping seasons for wolves and directed that gray wolf hunting and trapping seasons be held starting in the fall of 2012. The first hunting and trapping seasons of wolves were conducted during October–December 2012. Wolves are now being managed under a 1999 gray wolf management plan (WDNR 1999) with addenda in 2006 and 2007, but the plan is being updated to reflect these recent changes in gray wolf management in Wisconsin. A historical record for the U.S. Endangered winged mapleleaf mussel (*Quadrula fragosa*) exists for the Baraboo River here, but recent searches have not relocated the species, and it is now considered extirpated from this ecological landscape. The eastern massasauga rattlesnake and the bullhead (sheepnose) mussel (*Plethobasus cyphyus*)[1] are being considered for federal listing. Both are listed as Wisconsin Endangered species and occurred, or may still occur, here. The Bald Eagle (*Haliaeetus leucocephalus*) (formerly U.S. Threatened) is also found here. The species was federally delisted in 2007 and is protected under two federal laws: the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. It is listed as a Wisconsin species of special concern.

Wisconsin Endangered Species: Wisconsin Endangered species documented here (WDNR 2009) include four birds: Loggerhead Shrike (*Lanius ludovicianus*), Red-necked Grebe (*Podiceps grisegena*), Forster's Tern (*Sterna forsteri*), and Barn Owl (*Tyto alba*); five herptiles: northern cricket frog (*Acris crepitans*), western slender glass lizard (*Ophisaurus*

[1]When this material was written, it was based on the 2009 Wisconsin Natural Heritage Working List (WDNR 2009). Bullhead (sheepnose) mussel was listed as U.S. Endangered in 2012, and northern long-eared bat was listed as U.S. Threatened in 2015.

attenuatus), eastern massasauga, ornate box turtle (*Terrapene ornata*), and western ribbonsnake (*Thamnophis proximus*); one fish: goldeye (*Hiodon alosoides*)—documented only at the edge of the ecological landscape in the Wisconsin River in the tailwaters of the Prairie du Sac dam; one mussel: bullhead (sheepnose); and five other invertebrates: swamp metalmark (*Calephelis muticum*), silphium borer moth (*Papaipema silphii*), regal fritillary (*Speyeria idalia*), Wallace's deepwater mayfly (*Spinadis simplex*), and red-tailed prairie leafhopper (*Aflexia rubranura*). No Wisconsin Endangered mammals occur in this ecological landscape.

■ ***Wisconsin Threatened Species:*** No Wisconsin threatened mammals occur in this ecological landscape[2]. The Wisconsin Natural Heritage Working List (WDNR 2009) lists eight Wisconsin threatened birds that occur here: Henslow's Sparrow (*Ammodramus henslowii*), Red-shouldered Hawk (*Buteo lineatus*), Yellow Rail (*Coturnicops noveboracensis*), Cerulean Warbler (*Setophaga cerulea,* listed as *Dendroica cerulea* on the Natural Heritage Working List), Acadian Flycatcher (*Empidonax virescens*), Yellow-crowned Night-heron (*Nyctanassa violacea*), Greater Prairie-Chicken, and Bell's Vireo (*Vireo bellii*) and two threatened herptiles: wood turtle (*Glyptemys insculpta*) and Blanding's turtle (*Emydoidea blandingii*). Seven threatened fish are listed in the Natural Heritage Working List occur in this ecological landscape: black buffalo (*Ictiobus niger*), longear sunfish (*Lepomis megalotis*), redfin shiner (*Lythrurus umbratilis*), shoal chub (*Macrhybopsis aestivalis*), greater redhorse (*Moxostoma valenciennesi*), pugnose shiner (*Notropis anogenus*), and blue sucker (*Cycleptus elongatus*), but the blue sucker is only found on the very edge of the ecological landscape in the Wisconsin River in the tailwaters of the Prairie du Sac dam. Recent surveys found the river redhorse (*Moxostoma carinatum*) in the Fox River below Princeton. Four mussels, rock pocketbook (*Arcidens confragosus*), monkeyface (*Quadrula metanevra*), salamander mussel (*Simpsonaias ambigua*), and buckhorn (*Tritogonia verrucosa*), and two insects, spatterdock darner and prairie leafhopper (*Polyamia dilata*), have been documented within the ecological landscape.

■ ***Wisconsin Special Concern Species:*** Wisconsin Special Concern species include 4 mammals, 16 birds, 9 herptiles, 9 fish, and 38 invertebrate species (WDNR 2009; see Appendix 9.C for complete species list).

[2]On 6/1/2011, four bats were added to the Wisconsin Threatened species list: big brown bat (*Eptesicus fuscus*), little brown bat (*Myotis lucifugus*), northern long-eared bat (*Myotis septentrionalis*), and eastern pipistrelle (*Perimyotis subflavus*). This was an emergency listing due to the rapid spread of the often fatal disease known as white-nose syndrome. The four Wisconsin "cave" bats are especially vulnerable because they may travel great distances and spend time together in confined spaces, hibernating over the winter in caves and mines where they can become infected with the fungus that causes white-nose. Some hibernacula have experienced mortality rates greater than 98%. Northern long-eared bat occurs in this ecological landscape.

■ **Species of Greatest Conservation Need.** Species of Greatest Conservation Need (SGCN) are those that are listed in the Wisconsin Wildlife Action Plan (WDNR 2005). SGCN include species already recognized as endangered, threatened, or special concern on state or federal statutory lists, along with other species that meet SGCN criteria. There are 8 mammals, 45 birds, 8 herptiles, and 7 fish species listed as SGCN that have a high or moderate probability of occurring in the Central Sand Hills Ecological Landscape (see Appendix 9.E for a complete list of Species of Greatest Conservation Need in this ecological landscape).

■ **Responsibility Species.** Wisconsin has the best opportunity to preserve the globally imperiled and U.S. Endangered Karner blue butterfly. The Karner blue and barrens habitats that support the larval food plant, wild lupine, should be protected according to the guidelines in the U.S. Fish and Wildlife Service's Habitat Conservation Plan.

The ornate box turtle occurs in only one other ecological landscape in Wisconsin (Western Coulees and Ridges). Its habitats, sand prairie and oak barrens, should be protected in sufficient amounts at sites where viable populations of this species can be maintained.

The western slender glass lizard is known primarily from this ecological landscape and the Central Sand Plains Ecological Landscape in Wisconsin (with a few records from the Western Coulees and Ridges). Sand prairie and oak savanna habitats, both of which are now rare, should be preserved in sufficient amounts to maintain this species in Wisconsin.

The swamp metalmark butterfly occurs only in alkaline wetlands such as Calcareous Fen, some sedge meadows, and

The ornate box turtle (Wisconsin Endangered) has a very limited Wisconsin distribution. It occurs in only two of our ecological landscapes, including the Central Sand Hills. It is dependent on the habitat provided by unfragmented Sand Prairie and Oak Barrens communities. Photo by Rori Paloski, Wisconsin DNR.

The spatterdock darner (Wisconsin Threatened) is known in Wisconsin only from three ponds in the Central Sand Hills, each of them supporting the globally rare Coastal Plain Marsh natural community. Photo by David Marvin.

Significant Wildlife in the Central Sand Hills Ecological Landscape

- Rare species (including Karner blue butterfly, ornate box turtle, western slender glass lizard, swamp metalmark, and spatterdock darner).
- Wetland (fen, sedge meadow, marsh, shrub swamp) wildlife (e.g., Sandhill Crane, Yellow Rail, Blanding's *turtle*, pickerel frog, American Bittern, American Woodcock, Blue-winged Warbler, Black Tern, Forster's Tern, Golden-winged Warbler, Rusty Blackbird).
- Oak woodland, oak savanna, and grassland wildlife (e.g., gophersnake, ornate box turtle, western slender glass lizard, Red-headed Woodpecker, Blue-winged Warbler, Brown Thrasher, Black-billed Cuckoo, Bobolink, Eastern Meadowlark, Field Sparrow, Grasshopper Sparrow, Henslow's Sparrow, Lark Sparrow, Upland Sandpiper, Vesper Sparrow, Western Meadowlark, Eastern Whip-poor-will, Franklin's ground squirrel, gorgone checkerspot, and Leonard's skipper).
- Rare Coastal Plain Marsh wildlife (e.g., spatterdock darner, ringed boghaunter, sand snaketail, and warpaint emerald).
- Medium to large rivers and floodplains fish and wildlife (e.g., lake sturgeon, shoal chub, black buffalo, western sand darter, midland softshell turtle, Osprey, Bald Eagle, Prothonotary Warbler, and Red-shouldered Hawk).
- Coldwater streams and streamside vegetation that support fish and insects such as brook trout, eastern red damsel, river bluet, and swamp metalmark.

semi-open tamarack swamps that support swamp thistle (*Cirsium muticum*), the larval food plant. In Wisconsin the swamp metalmark is now known only from Fond du Lac, Marinette, Marquette, Ozaukee, and Washington counties.

The spatterdock darner dragonfly is known to occur in Wisconsin only in the Central Sand Hills, where it has been found in three ponds in Marquette County. Breeding has been documented in only one of these ponds. Wisconsin is on the western edge of the range of this species. The spatterdock darner is uncommon and local within a range restricted to the northeastern United States and southern Ontario but is considered globally secure.

Socially Important Fauna. Species such as white-tailed deer (*Odocoileus virginianus*), American beaver (*Castor canandensis*), North American river otter (*Lontra canadensis*), Ruffed Grouse (*Bonasa umbellus*), American Woodcock (*Scolopax minor*), Wild Turkey (*Meleagris gallopavo*), and Sandhill Crane and other waterbirds are all important here for hunting, trapping, and wildlife viewing. This ecological landscape has an important warmwater fishery that supports populations of walleye plus both smallmouth and largemouth bass as well as bluegill (*Lepomis macrochirus*), yellow perch (*Perca flavescens*), and other panfish sought by anglers. Some coldwater streams support populations of native brook trout as well as introduced brown trout.

Wildlife Habitats and Communities. Important wildlife species are associated with dry forest and oak savanna, wetlands (fens, sedge meadows, and marshes), surrogate grasslands, floodplain forests, large rivers (Wisconsin and lower Baraboo rivers), and coldwater streams. Six Important Bird Areas have been designated within or partially within the Central Sand Hills Ecological Landscape (Steele 2007; see the map entitled "Ecologically Significant Places of the Central Sand Hills" in Appendix 9.K at the end of this chapter).

Upland forest occurs on sandy soil and is primarily composed of oaks or mixtures of oaks and pines. This is one of two landscapes in which Central Sands Pine-Oak Forest occurs and in which this community can be managed over time. Historically, oak forest covered over half the area. Now agriculture covers about a third of the area, but there still is almost a third of the landscape in upland forest with opportunities to manage for wildlife species that use oak and mixed pine-oak forest. Maintaining or restoring mixed pine-oak forests to represent the full range of patch sizes and age classes would be desirable. Birds using larger stands of this habitat include Pileated Woodpecker (*Dryocopus pileatus*), Red-headed Woodpecker (*Melanerpes erythrocephalus*), Eastern Whip-poor-will (*Caprimulgus vociferus*), Wood Thrush (*Hylocichla mustelina*), Scarlet Tanager (*Piranga olivacea*), Yellow-throated Vireo (*Vireo flavifrons*), Blue-gray Gnatcatcher (*Polioptila caerulea*), Eastern Wood-Pewee (*Contopus virens*) and Ovenbird (*Seiurus aurocapilla*). Heavily cut stands would support a very different assemblage, which

might include Brown Thrasher (*Toxostoma rufum*), Eastern Towhee (*Pipilo erythrophthalmus*), Chestnut-sided Warbler (*Setophaga pensylvanica*), Northern Flicker (*Colaptes auratus*), and Field Sparrow (*Spizella pusilla*).

Historically, a mosaic of oak woodland, oak savanna, and native prairie covered almost a quarter of the area and supported a diverse array of wildlife species. Today much of the oak woodland, oak savanna, and prairie has been converted to agricultural production or succeeded to oak forest after the implementation of fire suppression policies early in the 20th century. However, there are still good opportunities to manage for oak woodland, oak savanna, and native and surrogate grassland complexes. Managing oaks as a large-scale mosaic of patches along a successional gradient that includes forest, woodland, and savanna, along with native or surrogate grassland, is desirable. Wildlife species that would potentially benefit from such management include gophersnake (*Pituophis catenifer*), ornate box turtle, western slender glass lizard, Red-headed Woodpecker, Blue-winged Warbler (*Vermivora cyanoptera,* listed as *Vemivora pinus* on the Wisconsin Natural Heritage Working List), Brown Thrasher, Black-billed Cuckoo, Bobolink (*Dolichonyx oryzivorus*), Eastern Meadowlark (*Sturnella magna*), Field Sparrow, Grasshopper Sparrow (*Ammodramus savannarum*), Henslow's Sparrow, Lark Sparrow (*Chondestes grammacus*), Northern Harrier (*Circus cyaneus*), Short-eared Owl, Upland Sandpiper (*Bartramia longicauda*), Vesper Sparrow (*Pooecetes gramineus*), Western Meadowlark (*Sturnella neglecta*), Eastern Whip-poor-will, eastern red bat (*Lasiurus borealis*), Franklin's ground squirrel (*Spermophilus* [*Poliocitellus*] *franklinii*), northern long-eared bat (*Myotis septentrionalis*), Karner blue butterfly, gorgone checkerspot (*Chlosyne gorgone*), and Leonard's skipper.

There is a high concentration of coldwater streams emanating from end moraine landforms, with associated streamside vegetation of sedge meadow, low prairie, fen, shrub swamp, and tamarack swamp. Wetlands were created and are maintained by the continuous discharge of calcareous groundwater from the end and recessional moraines in this ecological landscape. These coldwater streams make this area of continental significance (WDNR 2008b). They are important habitats for species such as brook trout, swamp metalmark, and two damselflies, the eastern red damsel (*Amphiagrion saucium*) and river bluet (*Enallagma anna*). Maintaining stream hydrology and wetland habitat will also provide habitat for additional wildlife species, such as Blanding's turtle, pickerel frog (*Lithobates palustris*), American Bittern (*Botaurus lentiginosus*), American Woodcock, Blue-winged Teal (*Anas discors*), Black-billed Cuckoo (*Coccyzus erythropthalmus*), Willow Flycatcher (*Empidonax traillii*), eastern red bat, and northern long-eared bat.

Large sedge meadows and the shrub-carr and tamarack swamp habitats that often border them provide habitat for many wildlife species. Preserving these large sedge meadows and surrounding habitats will benefit Blanding's turtle, pickerel frog, American Bittern, American Woodcock, Blue-winged Warbler, Blue-winged Teal, Black-billed Cuckoo, Northern Harrier, Rusty Blackbird (*Euphagus carolinus*), Willow Flycatcher, eastern red bat, northern long-eared bat, Leonard's skipper (*Hesperia leonardus*), Black Tern (*Chlidonias niger*), Forster's Tern, Golden-winged Warbler (*Vermivora chrysoptera*), Le Conte's Sparrow (*Ammodramus leconteii*), Northern Harrier, Short-eared Owl (*Asio flammeus*), and Whooping Crane (*Grus americana*).

The Wisconsin distribution of the globally rare Coastal Plain Marsh community is limited to only a few ecological landscapes, with most occurrences in the Central Sand Hills. Landforms supporting Coastal Plain Marsh include extinct glacial lakebeds, glacial outwash sands, and, possibly, glacial tunnel channels. The lake or pond waters are nutrient-poor ("soft") and acidic, and all known occurrences of the community are small or, at most, medium-sized (one to a few tens of acres). Rare animals that occur at these sites include dragonflies such as the spatterdock darner, ringed boghaunter, sand snaketail, and warpaint emerald. The ringed boghaunter and sand snaketail are globally rare—as is the community they inhabit.

Large warmwater rivers such as the Wisconsin, from Wisconsin Dells to Lake Wisconsin, and the lower Baraboo, with their associated complex floodplains, provide habitat for many fish and wildlife species. Maintaining water quality, water quantity, and protecting or restoring in-stream and floodplain habitats, will ensure that this protection will continue. The segment of the Wisconsin River in the Central Sand Hills Ecological Landscape supports the most viable lake sturgeon population in the entire Wisconsin River system and also holds strong populations of the Wisconsin Threatened shoal chub and black buffalo, the Wisconsin Special Concern western sand darter (*Etheostoma clarum*), plus smaller populations of other rare fishes such as the mud darter (*Etheostoma spectabile*) and pirate perch (*Aphredoderus sayanus*). Currently, fish are "trapped" within this relatively short stretch of the Wisconsin River between the Wisconsin Dells and Prairie du Sac dams, but fish passage structures are scheduled to be installed at the Prairie du Sac dam by 2015 as part of the Federal Energy Regulatory Commission (FERC) relicensing process. Other examples of noteworthy wildlife occurring here are midland smooth softshell turtle (*Apalone muticus*), Osprey (*Pandion haliaetus*), Bald Eagle, Red-shouldered Hawk, Cerulean Warbler, and Prothonotary Warbler (*Protonotaria citrea*).

Natural and Human Disturbances

Fire, Wind, and Flooding

Historically, fire was the most extensive and influential natural disturbance agent in the Central Sand Hills. The abundance of prairies, barrens, oak openings, and oak forests early in the Euro-American settlement period indicates that fires were formerly frequent throughout much of the ecological landscape. Present-day fires are typically ignited by humans but spread and become large fires only in areas with dry sandy

soils that lack firebreaks such as streams, lakes, and wetlands (Cardille et al. 2001).

Studies of fire history prior to Euro-American settlement are lacking in this ecological landscape. Comparisons to other fire-prone landscapes in the Lake States are problematic as this area receives less precipitation than similar landforms in Lower Michigan, and the climate is warmer than the sand plains of northern Wisconsin. Features of the original landscape that influenced the ability for fire to spread have been modified by drainage in some areas and construction of impoundments in others, and peatlands have lost surface elevation due to repeated fires and decomposition during the last century. These changes make it difficult to estimate fire intervals and intensities prior to Euro-American settlement, but estimates of fire intervals obtained elsewhere in the Great Lakes region may provide an indication of the range of fire intervals here.

Before Euro-American settlement, the frequency of recurrence of stand-replacing fires ranged from 75 to 250 years for mixed pine-oak-aspen forests in parts of the Lake States with diverse landscape firebreaks (Dickmann and Cleland 2002). In northeastern Lower Michigan, historical fire intervals in mixed pine forests were 129–258 years and in oak-pine forests were 172–344 years (Whitney 1986). Simard and Blank (1982) found that fire intervals for jack pine forests in the highly flammable Mack Lake area of Michigan averaged 27 years during the time period prior to Euro-American settlement. At Itasca State Park in Minnesota, jack pine forests burned at an interval of about 22 years (Frissell 1973).

Various tribes of American Indians have occupied the Central Sand Hills since the last glacial period, utilizing the abundant food resources of the area, cultivating crops on the fertile floodplains, and building settlements on higher landforms. These tribes used fire as a tool in creating desirable vegetation, clearing land, driving game, and for other reasons. Modern data on lightning strikes (1982 to 2012) show relatively few occurrences in most of the low-lying landscape of the Central Sand Plains, with the incidence being slightly higher in Wood and Portage counties (NOAA 2014), so it is certain that prehistoric fire intervals in this ecological landscape had a strong human influence.

We know that fire was a frequent occurrence in the Central Sand Hills prior to Euro-American settlement and that fire return intervals varied depending on soils, water tables, patch sizes of flammable vegetation, and the customs of the people who lived here then. In the driest portions of the ecological landscape, where vegetation was dominated by oak barrens or jack pine-oak barrens, experts believe that stand-replacing fires occurred at roughly 25- to 50-year intervals, along with low-intensity surface fires at intervals of two to four years (A. Haney, University of Wisconsin-Stevens Point, personal communication). In mixed pine-oak systems that developed into oak opening or forest, surface fires would have occurred somewhat less frequently, perhaps every seven to ten years. These fire intervals are estimated based on information from other parts of the Midwest and on studies of prescribed burning used to recreate the structure and composition of barrens (Reich et al. 1990, Nielsen et al. 2003). Longer stand-replacing fire intervals of 75 to 250 years, in combination with more frequent surface fires, would have been likely in areas with fire barriers of streams, lakes, and wetlands (or more complex topography), leading to development of eastern white pine, oaks, or swamp forests. Wetlands also could have burned when very dry conditions were accompanied by strong winds, as is sometimes seen in modern fires (e.g., the Ham Lake fire in Minnesota, May 2007).

Prescribed burning has been used successfully in the Central Sand Hills Ecological Landscape to restore grassland and barrens, but in some areas the presence of homes and other structures, land ownership patterns, and/or dense, highly flammable vegetation makes the use of fire difficult. Managers often regenerate oak and pine forests through clearcutting, which partially resembles the effects of fire as both are disturbances that open the site to full sunlight. Fire is different from clearcutting in that it reduces the density of saplings, shrubs, and herbaceous litter, providing a competitive advantage for some regenerating tree (e.g., oak) and herb species. Fire also mineralizes organic material, making nutrients available for plant uptake or leaching, whereas logging removes a portion of site nutrients. Pine forests often are regenerated using intensive site preparation and/or planting, often leading to major changes in floristic composition.

Windthrow disturbance occurred in historical forests of the Central Sand Hills, but data on frequency and severity are lacking. Windthrow may have been relatively common in the tamarack swamps and in bottomland forests along rivers and streams where the high water table contributed to limiting tree rooting depths.

The extent and frequency of flood disturbance prior to Euro-American settlement is unknown. Flood events in this ecological landscape occurred during early settlement, before extensive modifications to the rivers took place. It is possible that river flows at this time could have already become flashy due to deforestation in surrounding watersheds because eastern white pine had been harvested heavily since the 1830s. River velocity was significantly slowed over the next few decades by dam construction, and later floods on this portion of the Wisconsin River were less severe (Taylor 1934). A levee system was built to protect agricultural lands near Portage from Wisconsin River floods (see the "Changes in Hydrology" section below).

Forest Insects and Diseases

The forests of the Central Sand Hills are dominated by oaks, with some conifers (pines, on the uplands), aspens, and swamp species (silver maple [*Acer saccharinum*], green ash [*Fraxinus pennsylvanica*], river birch in the floodplains, tamarack in peatlands or on mucks). Each of these trees is associated with particular insects and diseases. There are a number of pest species that periodically affect forests in this ecological landscape.

Gypsy moth (*Lymantria dispar*) is a nonnative insect that is currently becoming established in this ecological landscape and will periodically affect oak and aspen forests. Dry conditions in this ecological landscape can facilitate gypsy moth population growth, leading to faster rates of spread and more frequent outbreaks once the pest has been established. The two-lined chestnut borer (*Agrilus bilineatus,* is a bark-boring insect that attacks oaks. Oak wilt is a vascular disease caused by the native fungus *Ceratocystis fagacearum*. Aspen can be impacted by forest tent caterpillar (*Malacosoma distria*), aspen heart rot fungus (*Phellinus tremulae*) and aspen hypoxylon canker fungus (*hypoxylon mammatum*).

Conifers, including red, eastern white, and jack pines, can be affected by Annosum root rot, which is caused by the fungus *Heterobasidion annosum* and often occurs in plantations. Red pines are also subject to pocket mortality, caused by a complex of insects and the fungal species *Leptographium terrebrantis* and *L. procerum*. Pocket mortality decline is more common in southern Wisconsin than in the north, possibly because trees are stressed by climate conditions that are less than ideal for this species. Red pine is also susceptible to Diplodia pine blight fungus (*Diplodia pinea*) and pine sawfly (*Neodiprion* spp., *Diprion* spp.). White pine blister rust is an introduced fungal disease caused by *Cronartium ribicola* that is most severe in low-lying areas. Jack pine budworm (*Choristoneura pinus*) is a native insect whose infestations can cause large-scale mortality of mature jack pine, setting up fuel conditions for catastrophic fire.

Tamarack is attacked by a variety of insect pests that can occasionally kill large patches of tamarack forest. These pests include eastern larch beetle (*Dendroctonus simplex*), larch sawfly (*Pristiphora erichsonii*), and the nonnative larch casebearer (*Coleophora laricella*).

The emerald ash borer (*Agrilus planipennis*) is not expected to have as great an impact on forest structure here as in many other ecological landscapes in the state. Ash species are relatively minor components of the forest communities in the Central Sand Hills, so most forests in this ecological landscape are not at high risk from emerald ash borer. However, green ash is common and sometimes a canopy co-dominant in the forested floodplains of the Wisconsin and Baraboo rivers. Although Floodplain Forests do not comprise a large percentage of the forested land here, they provide important breeding habitat for a number of specialists, including rare species, and also maintain connectivity between forested sites within and between ecological landscapes.

More information about these forest diseases and insect pests of forest trees can be found at the Wisconsin DNR's forest health web page (WDNR 2015a) and at the U.S. Forest Service Northeastern Area forest health and economics web page (USFS 2015).

Invasive Species

Nonnative Eurasian buckthorns such as glossy buckthorn and common buckthorn (*Rhamnus cathartica*) are serious problems and have become dominant understory plants in some forests and wetlands. Nonnative honeysuckles (*Lonicera tatarica*, *L. morrowii*, and *L.* x *bella*) and garlic mustard (*Alliaria petiolata*) are also problematic at some locations and are likely to spread. These species may initially colonize disturbed areas and edges but once established can spread and continue to invade surrounding habitats even in the absence of additional disturbance. Gypsy moth and emerald ash borer (see comments in previous section) could potentially become more serious problems in the near future.

In grasslands, including native prairies and semi-open savannas, spotted knapweed (*Centaurea biebersteinii*) is sometimes the dominant herb in disturbed areas with sandy soils. Leafy spurge (*Euphorbia esula*) and cypress spurge (*Euphorbia cyparissias*) occur on dry to dry-mesic upland sites; they have been documented in Sand Prairie, Dry Prairie, Dry-mesic Prairie, Oak Barrens, Pine Barrens, and in some oak- or pine-dominated forests and woodlands. These exotic spurges and knapweeds are also common in some surrogate grasslands here, which are important habitats for grassland birds and other species of conservation concern. Control measures should probably be prioritized, with natural communities that are otherwise in good condition, vegetation/habitats that are especially vulnerable to significant loss of native plant and animal diversity, and large sites that are important to sensitive animals but that are not yet overrun among the potential top priorities active invasives control. All ecologically important sites should be monitored periodically for the presence of invasives, and control efforts, at least for some invasive species, are likely to be more cost effective and successful when implemented early. There are many more nonnative species now present in the Central Sand Hills Ecological Landscape, but at this time their potential adverse effects are less certain than those of the species specifically mentioned above.

In aquatic and wetland ecosystems, the primary problem species include reed canary grass, glossy buckthorn, purple loosestrife (*Lythrum salicaria*), common reed, Eurasian water-milfoil, curly-leaf pondweed, common carp, and rusty crayfish (*Orconectes rusticus*). Common carp continue to cause major problems in shallow lakes by uprooting and destroying beds of native aquatic plants and suspending fine sediments and associated nutrients. Large amounts of money and effort have been spent to control carp in Central Sand Hills Ecological Landscape, most recently using whole-lake poisoning to kill all the carp and replace them with more desirable native species. Water level drawdowns are often used prior to treatment to concentrate carp into smaller areas to increase the effectiveness of the chemical treatment. It is unclear if other aquatic organisms that are affected by such treatments have recolonized and recovered on their own. Better understanding of these secondary impacts of such treatments is needed.

For more information on invasive species, see the Wisconsin DNR's invasive species web page (WDNR 2015c).

Land Use Impacts

Historical Impacts. Humans have been a driving force in shaping ecosystem structure and composition in this ecological landscape even before recorded history. Fires were frequent here, often set by American Indians for hunting and to improve habitat for animals on which they depended (e.g., white-tailed deer) (Bray 1995).

In the early 20th century, large-scale drainage projects, as well as the construction of dams and impoundments, altered the physical environment with cascading effects on vegetation, wildlife, and natural disturbances. Fire suppression activities, also begun in the early 20th century, have reduced and almost eliminated fire frequency and intensity, leading to changes in vegetation composition and structure and in landscape patch structure. Fire suppression has allowed open and semi-open vegetation types such as prairies and oak savannas to succeed to dense forests of oak or sometimes pine. Agricultural activities resulted in the conversion of many native communities to farm fields and pastures.

The Portage levee system consists of 13.8 miles of discontinuous sand dikes that were constructed along the Wisconsin River during the 1890s by various groups of landowners that lived adjacent to the river. The Caledonia levee consists of two segments totaling 9.6 miles along the south side of the Wisconsin River, and the Lewiston levee consists of four segments totaling 4.2 miles on the north side of the river. The height of the levees is typically 8 to 12 feet. The levees were built from locally available materials without any engineering design or adherence to any design standards. These levees were intended to protect adjacent lands from periodic flood events of the Wisconsin River. A recent analysis indicated that the level of flood protection provided by these levees was minimal and not cost effective compared to the costs of maintaining the levees (WDNR 2007a). The preferred recommendation of this report was to incrementally remove the levees after residences that are in the floodplain were purchased from voluntary sellers and restore natural water flow and floodplain communities.

Current Impacts. Current disturbances are largely due to human activities, primarily agriculture, timber production/harvest, and residential development**.** Human disturbance includes the long-term conversion of land to roads, buildings, and utility corridors, actions that have fragmented formerly connected ecosystems. Impoundments, created in the past for power generation, flood control, and waterfowl habitat, often inundated sedge meadows, wet prairies, lowland forests, peatlands, and other native communities. Shorter-term disturbances result from logging and recreational pursuits such as ATV use.

A major difference between current and historical disturbances is that today's impacts are multiple and pervasive, affecting much of the landscape almost constantly. Another major difference is that many of the present disturbances never occurred in this ecological landscape prior to Euro-American settlement. Examples include ditches, dikes, roads and railways, excessive nutrient and sediment inputs, intensive cultivation at large-scales, groundwater withdrawals, and introduction of invasive species.

In addition to direct impacts, human land use changes also indirectly impact ecosystem composition, structure, and function by altering natural disturbance regimes. Because many swamp and bottomland forests have been converted to other land uses, wind disturbance is likely reduced from historical conditions. Construction of dams on major rivers has disrupted the historical flood regime of floodplain vegetation, likely leading to changes in species composition and structure and interference with nutrient cycling and the deposition and scouring of sediments. The other major effects of dams are blockage of movement by fishes and other aquatic organisms, fragmentation of riverine habitats, and direct conversion of riverine habitat to lake-like habitats. Dams can increase water temperature and affect fish habitat by changing flow velocities and altering substrate type.

Agriculture. Prior to Euro-American settlement, this ecological landscape was characterized by a mosaic of prairie, oak savanna, hardwood forest, sedge meadow, and marsh. Almost all of the prairie and oak savanna and some of the sedge meadow has been converted to agricultural uses. In some areas, tamarack swamps were drained and the lands used for muck farming. In 1992, agricultural crops occurred on approximately 34% of all land in the Central Sand Hills, and another 19% was grassland, mostly pasture (WDNR 1993). The spread of center pivot irrigation has boosted crop productivity on droughty soils and has increased the amount of land converted to agricultural production. This has altered landscape patterns and led to more widespread use of herbicides, pesticides, and fertilizers. Widespread agriculture has created a ***matrix*** of farm fields, interspersed with small, scattered patches of forest and wetland. This benefits common and widely distributed species such as white-tailed deer and Wild Turkey but does not provide habitat for area-

Central Wisconsin muck farm. Drained peatlands have been converted to intensive agricultural use in some areas. Photo by Eric Epstein, Wisconsin DNR.

sensitive grassland or forest interior species or many other habitat specialists. Because of intensive agricultural practices and urban/rural residential land uses, grassland bird habitat is largely restricted to idle grasslands on publicly owned properties and on unfarmed, privately owned grasslands such as wet meadows. Large-scale grassland-wetland management sites on public lands include Comstock Bog-Meadow State Natural Area, Germania Marsh Wildlife Management Area, and Grand River Marsh Wildlife Area.

Groundwater contamination via agricultural chemicals has been an issue in portions of the Central Sand Hills. Because of the highly permeable sandy soils in parts of this ecological landscape, agricultural chemicals can quickly leach into the groundwater and become a problem in wells supplying drinking water to residents. Recently, Atrazine, an herbicide commonly used to control weeds in corn fields, has been identified as a problem in some areas.

Changes in Hydrology. Wetlands were abundant in the Central Sand Hills prior to settlement of the area by Euro-Americans, covering 18% of the ecological landscape. These wetlands, along with the prairies, made the Central Sand Hills very important for waterfowl and other wetland fauna. Subsequent to settlement of the region by Euro-Americans, wetlands were drained for agricultural and residential purposes, and many of the upland prairies were plowed. While such activities were viewed as having obvious social benefits with little or no downside, they led to the damage or impairment of many wetlands and some waterbodies by lowering water tables, channeling water, and fragmenting habitats. This has damaged, diminished, or caused the loss of native ecosystems such as sedge meadows, wet prairies, and shallow marshes. Ditching altered hydrology and vegetation and damaged or destroyed native wetland plant communities and important wildlife habitat. Straightening stream channels (channelization) increases stream velocity, disturbs or eliminates some in-stream and streamside habitats, and ultimately contributes to increased bank erosion downstream flooding. Channelized streams are poor habitat for most aquatic organisms.

According to the Wisconsin Wetlands Inventory, wetlands cover approximately 254,000 acres (18%) of the ecological landscape today (WDNR 2010c). Forested wetlands make up over 107,000 acres of the ecological landscape, making these the most abundant wetlands in the Central Sand Hills. Wet meadows (including emergent marsh and sedge meadow as well as disturbed stands dominated by reed canary grass) occupy approximately 81,000 acres. Shrub/scrub wetlands occur across approximately 56,000 acres. Some of the larger wetlands here are Comstock-Germania Marsh and Grand River Marsh. However, these wetlands continue to be degraded by excessive runoff of sediments, nutrients, herbicides, pesticides and other pollutants from agricultural and urban lands, changed hydrologic conditions, and the impacts of carp and other invasive species (e.g., reed canary grass, common reed, purple loosestrife, glossy buckthorn).

In addition to widespread wetland drainage, wetlands have also been flooded to increase waterfowl habitat. Converting wetland habitat from one type to another, such as changing a sedge meadow to an open water marsh, is not necessarily an improvement in wetland function, and it will diminish or eliminate habitat for species dependent on the "converted" habitat. While it is still a wetland, it may have fewer functional values than the original wetland (WDNR 2001). At the ecological landscape level, all native wetland types should be maintained in an appropriate range of patch sizes and protected from direct or indirect damaging activities that diminish their quality and impair function. Changing wetland hydrology by lowering the water table and eliminating periodic fire can cause sedge meadows, low prairies, and fens to succeed to shrub swamps. Large-scale assessments are needed to inform decisions involving converting one vegetation or habitat type to another.

Dams were constructed to generate power, mill grains, facilitate transportation by water, and create recreational opportunities. However, dams limit the movement of aquatic organisms, including game fish such as walleye, smallmouth bass, trout, and lake sturgeon (*Acipenser fulvescens*). Dams not only eliminate stream hydrology by creating a lake-like impoundment, they eliminate flowing water habitat and the cooler temperatures required by many species adapted to streams and rivers. As impounded waters behind dams warm, it allows ***rough fish*** such as carp to flourish while eliminating more desirable native species. These impacts can be reversed to a great extent by removing dams completely. For example, following removal of four dams on the Baraboo River, populations of carp declined, and native fish that had been present or more common historically either returned or increased (Catalano et al. 2007). Another option chosen for some streams where deeper water levels are desired is to replace a dam with a rock weir or "ramp" that creates a deeper pool yet maintains a current and allows for safe fish passage upstream and downstream.

Forest Management. Many forest patches are small to medium-sized and intermixed with agricultural crop land, wetlands, and nonnative grasslands, resulting in fragmented habitats or habitats that lack large patches or connections that were formerly present. Conversion of native forests, sand prairies, and oak savannas to pine plantations has been common in some areas. The use of herbicides to aid in the establishment of these plantations can reduce or eliminate native plants and some of the animals dependent on native flora. Management practices should be designed to maintain patch sizes and age structures necessary to maintain or restore native animals and avoid fragmentation, isolation, and simplification of habitats.

Lack of regeneration of some tree species in floodplain forests could be another significant problem here. The disruption of hydrologic regimes (frequency, magnitude, and timing of floods), introduction of invasive species such as reed canary

grass, loss of elms and structural changes to the canopy due to Dutch elm disease, and potential damage from the emerald ash borer may make regeneration of floodplain forests difficult. Floodplain forests could be lost and replaced by monotypic stands of reed canary grass or stands of weedy species such as box elder (*Acer negundo*).

The dominant tamaracks in many conifer swamps are failing to regenerate, and in some cases the canopy trees are dying. Hydrologic disruptions may be a major cause of mortality. Fire suppression, the increase in tall shrubs and deciduous saplings in areas formerly dominated by tamarack, excessive nutrient and sediment inputs, and changes in landscape context may also be contributing factors to tamarack decline, but the reasons these communities are no longer able to maintain themselves are presently uncertain. Research is needed to pinpoint the causes of decline and lack of regeneration in tamarack swamps and some bottomland hardwood forests.

Residential Development. Dispersed residential development can be found throughout the ecological landscape. Additional development has occurred around the shores of lakes and impoundments. This has resulted in habitat fragmentation and loss of connectivity between habitat patches. In many areas, destruction of the rare sand prairie and oak savanna habitats has taken place.

Management Opportunities for Important Ecological Features of the Central Sand Hills

Natural communities, waterbodies, and other significant habitats for native plants and animals have been grouped together as "ecological features" and identified as management opportunities when they

- occur together in close proximity, especially in repeatable patterns representative of a particular ecological landscape or group of ecological landscapes;
- offer important compositional, structural, and functional attributes that may not necessarily be represented in a single stand of any one community type;
- represent outstanding examples of natural features especially characteristic of a given ecological landscape;
- are adapted to and somewhat dependent on similar disturbance regimes;
- share hydrological linkage;
- offer opportunities for coordinated planning and management efforts that will increase the effective conservation area of a planning or management unit, reduce negative edge impacts, and/or connect otherwise isolated patches of similar communities or habitats;
- potentially increase ecological viability when environmental or land use changes occur by including environmental gradients, scale, and connectivity among other important management considerations;
- accommodate species needing large areas and/or those requiring more than one habitat;
- add habitat diversity that would otherwise not be present or maintained; and
- provide economies of scale for land and water managers.

A site's conservation potential may go unrecognized and unrealized when individual stands and habitat patches are managed as stand-alone entities. A landscape-scale approach that considers the context and history of an area, along with the types of communities, habitats, and species that are present, may provide the most benefits over the longest period of time. We do not mean to imply that all of the communities and habitats associated with a given opportunity should be managed in the same way, at the same time, or at the same scale. We suggest instead that planning and management efforts incorporate broader management considerations and address the variety of scales and structures approximating the ***natural range of variability*** appropriate for and feasible in an ecological landscape—especially those that are missing, declining, or at the greatest risk of disappearing over time.

Both ecological and socioeconomic factors were considered when determining management opportunities in the Central Sand Hills. Integrating ecosystem management with socioeconomic activities can result in efficiencies in the use of land, tax revenues, and private capital. This type of integration can also help to generate broader and deeper support for sustainable ecosystem management. Statewide integrated opportunities can be found in Chapter 6, "Wisconsin's Ecological Features and Opportunities for Management," in Part 1 of the book.

Significant ecological management opportunities that have been identified for the Central Sand Hills Ecological Landscape include

- fire-adapted ecosystems: oak forest, mixed pine-oak forest, Oak Woodland, oak savanna, prairie, sedge meadow, fen;
- Coastal Plain Marsh and Inland Beach (associated with soft-water seepage lake or pond);
- coldwater streams, springs, and spring runs;
- alkaline wetlands: fens, sedge meadows, Southern Tamarack Swamp;
- warmwater rivers and floodplain corridors;
- lakes, ponds, and impoundments;
- bedrock features: cliffs, talus slopes, bedrock glades; and
- miscellaneous opportunities including scattered natural communities and rare species populations.

Outstanding Ecological Opportunities in the Central Sand Hills Ecological Landscape

- Fire adapted ecosystems such as oak forests, oak woodlands, oak savannas, prairies, and sedge meadows are major management opportunities here.
- Coastal Plain Marsh and Inland Beach communities occur here and support many rare species, especially plants and invertebrates.
- A highly significant concentration of coldwater streams and springs occurs here.
- Alkaline wetlands are well represented here and include calcareous fen, sedge meadow, and tamarack swamp.
- Warmwater rivers and their associated floodplains offer important management opportunities.
- Soft-water seepage lakes and ponds, and hard-water drainage lakes are present.
- Bedrock features are not common but include good examples of cliffs, bedrock glades, and talus slopes.
- Miscellaneous opportunities include good examples of other natural communities, extensive surrogate grasslands, and scattered rare species populations.

Natural communities, community complexes, and important habitats for which there are management opportunities in the Central Sand Hills Ecological Landscape are listed in Table 9.2. Examples of some locations where these important ecological places may be found within this ecological landscape are on the "Ecologically Significant Places within the Central Sand Hills Ecological Landscape" map in Appendix 9.K at the end of this chapter.

Fire-adapted Ecosystems: Oak Forest, Mixed Pine-Oak Forest, Oak Woodland, Oak Savanna, Prairie, Sedge Meadow, Fen

Fire-adapted ecosystems were historically common and widespread in the Central Sand Hills. They are represented today by numerous remnants, usually fragments of formerly more extensive and better connected ecosystems. Important natural communities adapted to periodic fire include dry forests composed of oaks or, less frequently, mixtures of oaks and pines; savannas, including oak openings, oak barrens, and pine barrens; prairies; and wetlands such as sedge meadows and fens.

For practical purposes, in part because of the absence of public land holdings large enough to support the full spectrum of fire-adapted natural communities in the Central Sand Hills and because of changes to the vegetation, land use and ownership patterns, and landscape dynamics that followed Euro-American settlement, it may be useful to split the fire-adapted vegetation into three basic groups based on structure: forests, savannas, and grasslands.

Forests

Search for opportunities to protect sites with extensive forests that include older stands of oak, oak mixed with pine, or pine. Sites should ideally be large enough and situated so that prescribed fire can be used as a forest management tool and so that core areas of interior forest can be maintained to support species needing the habitat features provided by these forests. Where feasible and ecologically appropriate, incorporate woodland and savanna management into the overall management plan for the site and avoid creating hard edges unless there is a physical feature such as a lake, stream, wetland, or bedrock outcrop that would have been present under historical disturbance regimes.

Savannas

Almost all savannas in this ecological landscape are dry. Both Oak Openings and Oak Barrens were present historically and constituted the dominant vegetation in some parts of the Central Sand Hills. Pine Barrens, or barrens with a mixed tree composition of pines and oaks, should be expected in some areas. Structurally, the savannas are intermediate between densely canopied forests and the open grasslands. Maintaining the full spectrum of vegetation structures present on the landscape is an important consideration for at least some sites as all of the savannas are dynamic and managing them as static entities is difficult at best and does not allow for changing environmental conditions. It is also necessary to maintain the full range of patch sizes needed to support various taxa, and some ecological processes. The floristics of savanna remnants

Oak savanna and woodland managed with periodic prescribed burns. The open understory supports many native species adapted and somewhat dependent on periodic fire. Rocky Run Oak Savanna and State Fishery Area, Columbia County. Photo by Andrew Badje, Wisconsin DNR.

Table 9.2. *Natural communities, aquatic features, and selected habitats associated with each ecological feature within the Central Sand Hills Ecological Landscape.*

Ecological features[a]	Natural communities,[b] aquatic features, and selected habitats
Fire adapted ecosystems	Southern Dry Forest Southern Dry-Mesic Forest Central Sands Pine-Oak Forest Northern Dry Forest Northern Dry-Mesic Forest Oak Barrens Oak Opening Oak Woodland Pine Barrens Dry Prairie Sand Prairie Dry-Mesic Prairie Mesic Prairie Wet-mesic Prairie Northern Sedge Meadow Southern Sedge Meadow Calcareous Fen Surrogate Grasslands
Coastal plain marsh, inland beach, soft-water seepage lake/pond	Emergent Marsh Coastal Plain Marsh Inland Beach Inland Lake
Springs, headwater streams, coldwater streams, associated wetlands	Alder Thicket Southern Sedge Meadow Northern Sedge meadow Calcareous Fen Coldwater Stream Springs and Spring Runs
Alkaline wetlands	Southern Tamarack Swamp Alder Thicket Shrub-carr Wet Prairie Wet-Mesic Prairie Northern Sedge Meadow Southern Sedge Meadow Calcareous Fen Emergent Marsh Submergent Marsh
Warmwater rivers and their floodplains	Floodplain Forest Northern Hardwood Swamp Shrub-carr Southern Sedge Meadow Emergent Marsh Impoundment Warmwater River Warmwater Stream Riverine Lake
Bedrock features	Bedrock Glade Dry Cliff Moist Cliff Talus Slope

Continued on next page

Table 9.2, *continued.*

Ecological features[a]	Natural communities,[b] aquatic features, and selected habitats
Lakes: seepage lakes, drainage lakes, ponds	Tamarack Swamp Bog Relict Northern Sedge Meadow Open Bog Ephemeral Pond Inland Lake Spring Pond
Miscellaneous opportunities	Rare Species Small isolated occurrences of natural communities, emphasizing those that are rare, in especially good condition, and not represented adequately in the other categories.

[a]An "ecological feature" is a natural community or group of natural communities or other significant habitats that occur in close proximity and may be affected by similar natural disturbances or interdependent in some other way. Ecological features were defined as management opportunities because individual natural communities often occur as part of a continuum (e.g., prairie to savanna to woodland, or marsh to meadow to shrub swamp to wet forest) or characteristically occur within a group of interacting community types (e.g., lakes within a forested matrix) that for some purposes can more effectively be planned and managed together rather than as separate entities. This does not imply that management actions for the individual communities or habitats are the same.

[b]See Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin," for definitions of natural community types.

have not been as well studied in the Central Sand Hills as elsewhere in the state but deserve more attention as an aid to researchers, inventory staff, and managers identifying sites and selecting conservation projects with the highest potential for successful restoration (Pruka 1995, Leach and Givnish 1996, 1999).

Grasslands

The herb-dominated natural communities include all prairies, sedge meadows, and most calcareous fens. Surrogate grasslands might also be considered here, especially if they support rare or declining grassland species and can be managed compatibly with restoration efforts targeting open wetlands, prairie remnants, and oak savannas.

Any sites that contain outstanding examples of individual communities because of their size, condition, or the presence of priority species should be considered for management. Because of the dynamic nature of all fire-adapted communities, and in an attempt to accommodate future environmental changes and land use patterns, opportunities to manage in complexes that include prairie, savanna, woodland, some wetlands, and even forest are especially desirable. Structural variability is inherent in some of the fire-dependent communities, and they should not necessarily be managed as static entities; for example, use ranges of woody cover that will still accommodate sensitive species and ensure that large scattered trees or small groves are present on at least some managed sites.

Management Opportunities, Needs, and Actions

- A systematic upgrade of inventory information on the locations, extent, and condition of all of the fire-adapted communities is needed.
- Opportunities to manage sites containing the full array of the fire-adapted communities is desirable, though the number of potential projects of this sort will be limited by local ownership patterns, parcel size, fragmentation, and other factors. Nongovernmental organizations (NGOs) active in this ecological landscape will be key partners in the Central Sand Hills.
- Oak Openings, Oak Barrens, and Sand Prairies are high priorities for conservation and management in the Central

This sedge meadow is exceptional for its size and the biotic diversity it supports. In addition to the extensive sedge meadow, elements of fen, marsh, shrub swamp, and lowland forest are also present. Prescribed burn plans developed for such sites and their surrounding vegetation now incorporate many considerations that will better ensure the protection of fire-sensitive species during periods in their life cycles when they may be vulnerable to fire effects. Comstock Bog-Meadow State Natural Area, Marquette County. Photo by Eric Epstein, Wisconsin DNR.

Sand Hills Ecological Landscape. If opportunities to manage for Pine Barrens are identified, that community should also be treated as a high priority.

- Monitor sites where prescribed fire has been applied to restore community function, composition, and structure. This includes forests and savannas.
- Increase information sharing on the benefits of and barriers to using prescribed fire as a management tool.
- Identify sites at which the control of invasive species is possible and develop and implement management plans.
- Develop a network of private and public partners to identify and implement projects based on ecological priorities that are not currently being addressed.

Coastal Plain Marsh and Inland Beach

Coastal Plain Marsh is a rare herb-dominated wetland community that is better represented in the Central Sand Hills than anywhere else in Wisconsin, where it is at the extreme western edge of its range (Kost et al. 2007). The dominant plants are small to medium-sized graminoids (sedges, rushes, and a few grasses), but the associates include a diverse array of forbs. The flora includes a large number of disjunct plants, with ranges centered on either the Atlantic Coastal Plain of the eastern U.S. or the Gulf coast. Some of these disjuncts are very rare in the Upper Midwest, and rare invertebrates are also associated with this community.

Inland beach habitats, especially those bordering the shores of the soft-water seepage lakes characteristic of the ecological landscape, are exceptionally dynamic. Due to their close relationship with groundwater levels that change, sometimes dramatically, with cyclical dry and wet cycles, surface water levels may fluctuate as much as several meters over a period of years or decades. Inland beach areas provide habitat for a number of rarities adapted to these cyclical high and low water levels, including the U.S. Threatened/Wisconsin Endangered endemic Fassett's Locoweed.

In the Central Sand Hills, these communities do not always co-occur, but both are highly sensitive to and can be easily damaged by excessive groundwater withdrawals, stabilization of water levels (which eliminates some of the open unvegetated habitats needed periodically by some specialized beach herbs), sediment or nutrient-laden runoff, and the use of mechanized vehicles on beaches and in the littoral zones. In the Central Sand Hills, most occurrences of these communities are associated with soft-water seepage lakes occurring on pitted glacial outwash or glacial tunnel channel landforms.

Management Opportunities, Needs, and Actions

- Protect site hydrology and maintain the natural range of water level fluctuations needed to maintain these communities and prevent them from succeeding to another type or disappearing permanently.

In the Central Sand Hills Ecological Landscape, small ponds such as this may support unusual assemblages of invertebrates and vascular plants. Over time, natural water level fluctuations maintain suitable conditions for some of the habitat specialists. Photo by Andy Clark, Wisconsin DNR.

*Meadow beauty (*Rhexia virginica*) is one of the showier specialists associated with the globally rare Coastal Plain Marsh community. Photo by Thomas Meyer, Wisconsin DNR.*

- Protect water quality from excessive inputs of nutrients and sediments.
- Work with private landowners to protect shorelines, shallows, and adjacent uplands from activities that would directly or indirectly damage or degrade the community.
- Where feasible, protect entire lakes and shorelines known to harbor inland beach and coastal plain marsh communities and associated rare species populations.
- Where feasible, manage protected lakes and ponds as a continuum with the fire-dependent upland natural communities with which they are most often associated.
- Conduct a range-wide survey in Wisconsin for both Coastal Plain Marsh and Inland Beach communities. This would be focused on the Central Sand Hills, Northern Highland (Inland Beach only), and Northwest Sands ecological landscapes, with scattered locations elsewhere. Rare plants and invertebrates would be the focal points of such surveys. The Central Sand Plains might be included in such an effort. Even though natural lakes, ponds, and beaches are scarce there, surrogate habitats can support a subset of the rarities, disjuncts, and other species of interest.

Coldwater Streams, Springs, and Spring Runs

The terminal moraines of the Green Bay Lobe are the source of groundwater that feeds the many coldwater streams for which this ecological landscape is known. Some of these streams have been given partial protection from hydrological disruption by their inclusion within state fishery areas. While the state fishery areas are designed to provide public access to these recreational resources, it is now known that many of the springs, headwaters streams, and associated wetland vegetation have high ecological as well as recreational values. This is due in part to the calcareous nature of the groundwater feeding these waterbodies and the calciphilic plants that benefit from or require this condition. However, these streams and wetland complexes remain vulnerable to land use impacts such as concentrated animal feeding operations or high capacity wells sited within their watersheds. There is an opportunity to expand the protection of these streams through education and the strengthening of state groundwater and spring protection laws.

Springs, such as this complex emanating from a Waushara County end moraine, feed and maintain the highly significant concentration of coldwater streams in the Central Sand Hills Ecological Landscape. Photo by Tom Weisenberger.

Management Opportunities, Needs, and Actions

- Identify protection needs, opportunities, and priorities for coldwater streams.
- Expand protection along headwaters streams and around springs to include intact or restorable wetlands.
- Additional hydrological protection from high capacity wells may be needed at some sites if their ecological integrity and recreational values are to be maintained.
- Some of the high quality streams here may benefit from the establishment or expansion of stream buffers. Protection incentives, new or already on the books, may be an important means of accomplishing this.
- Where feasible, manage adjoining uplands in natural vegetative cover (forest, savanna, prairie). Where that is not possible or practical, manage lands to eliminate or reduce excessive sediment and nutrient loads.
- Maintaining sufficient water quantity is as important as maintaining high water quality through better siting or regulation of high capacity wells and prevention of excessive nutrient loading throughout coldwater watersheds.
- Local governments have some ability to protect groundwater recharge areas from the adverse impacts of development.
- Coordination among units of local government and institutions developing land can help minimize the impacts to coldwater habitats with properly located and designed stormwater control projects.
- The ecological impacts of some widespread nonnative species, such as water-cress (*Nasturtium officinale*), need clarification. Several very rare native plants occur primarily in spring or seepage habitats and may be negatively impacted by areas where dense growths of watercress have occurred.
- Conduct additional surveys of springs and headwaters streams to identify populations of associated wildlife Species of Greatest Conservation Need and rare flora.

Alkaline Wetlands

One of the Central Sand Hills' most prominent landforms is the terminal moraine (the Johnstown Moraine) of the glacier that formed the Green Bay Lobe. Calcareous material occurs in the glacial till, and in some areas, this is expressed in the alkaline nature of the groundwater and in the composition of wetlands such as sedge meadows, fens, and even some tamarack swamps.

Calcareous Fen, sedge meadow, open tamarack forest. Comstock Bog-Meadow State Natural Area, Marquette County. Photo by Eric Epstein, Wisconsin DNR.

Tamarack is presently declining at sites in this ecological landscape, as it is elsewhere in southern Wisconsin, for reasons that include hydrological disruption, infestations of invasive insects and plants such as glossy buckthorn, successional changes leading to the decline of conifers and an increase in deciduous shrubs and saplings, and perhaps, the exclusion of periodic fire.

There are excellent opportunities in the Central Sand Hills to preserve, restore, and manage for extensive emergent marsh, southern sedge meadow, wet and wet-mesic prairie, and calcareous fen communities (e.g., Germania and Comstock marshes, parts of the Fox River corridor) as well as for remnant tamarack swamps.

Management Opportunities, Needs, and Actions

- The key management consideration for maintaining wetlands here is to protect and maintain or restore site hydrology. Proper construction and placement of culverts at roads or other rights-of-way that cross wetlands can help maintain the hydrological integrity, as can the control of American beaver activity and agricultural runoff. Excessive groundwater withdrawals may have deleterious impacts on streams and wetlands, and these need to be understood prior to the implementation of development proposals involving groundwater withdrawals.
- Protect wetlands, especially those that are extensive or that support sensitive species associated with streams. On some of the public lands, stream protection has not extended beyond the minimum needed to protect immediate streambanks and provide public access. More comprehensive planning is needed and the benefits of protecting wetlands in such situations deserve a higher profile.
- Assist appropriate NGOs in developing projects focused on the protection and management of alkaline wetlands.
- Wild rice persists in the Upper Fox River basin on the West Branch of the Fond du Lac River. Other sites potentially suitable for the reintroduction of wild rice should be identified and evaluated. Wild rice was formerly more widely distributed here, e.g., in the formerly clear but now turbid Fox River in Green Lake County.
- Monitor sites with natural communities or species populations that are known or thought to be sensitive to climate change, hydrologic disruption, and the spread of invasive species. Better baselines are needed for wetland vegetation and should also be established for selected sensitive plants, invertebrates, herptiles, and birds.
- Clarify the reasons for tamarack decline in southern Wisconsin, develop a plan to protect existing stands, and restore stands where feasible. The historical role played by periodic wildfire in maintaining tamarack on the landscape is an area that is especially in need of investigation as so much of the vegetation in the Central Sand Hills was dependent on or in some way adapted to periodic wildfire.
- Assess muck farm restoration potential as some muck farms may be reaching the point where they no longer produce economically viable crops due to the need for applications of potash, phosphoric acid, and lime (Loehwing 1925, Lee et al. 1975).

Warmwater Rivers and Floodplain Corridors

The larger rivers here (lower Baraboo River, a portion of the central Wisconsin River, and the Fox River) have all been directly or indirectly affected by dam construction and other hydrological modifications, limiting some conservation opportunities. However, the large rivers support aquatic organisms that the coldwater and coolwater streams do not. The well-developed floodplains along the Wisconsin, Montello, and Baraboo rivers provide lowland habitats that do not occur in other riverine situations. In addition, the floodplain corridors may serve as important travelways and stopovers for dispersing and migrating organisms, and they are important ecological connectors between the Central Sand Hills and other ecological landscapes.

The Kilbourn (at Wisconsin Dells) and Prairie du Sac dams on the Wisconsin River pose a barrier to movement of fish and other aquatic species. These dams operate as run-of-the-river facilities, but river levels change in the Central Sand Hills based on the operation of the Castle Rock Dam upstream, which holds and releases water as a "peaking facility" (see the "Hydrology" section). These changes in water level can have a negative impact on water quality and fisheries habitat due to increased bottom scouring, bank erosion, and the flushing of spawning areas. There is a plan in place to provide fish passage upstream of the Prairie du Sac Dam by 2015 using a fish elevator at this dam site (Lamoreaux 2014, USFWS 2015), but there is now concern that the fish elevator would allow Asian carp to enter the upper reaches of the Wisconsin River.

Removal of more dams and drop structures on rivers and their tributaries in this ecological landscape can help

improve stream connectivity for aquatic organisms, stream habitat, and water quality and partially restore the hydrologic regime. The addition of fish passage structures around dams is another means of improving stream connectivity and allowing at least some movement of aquatic organisms when dams are left in place.

Important floodplain corridor management opportunities exist at Pine Island State Wildlife Area and the Leopold Reserve (both on the Wisconsin River), the Lower Baraboo River Waterfowl Production Area, Gumz Marsh, Montello River system, and the Fox River National Wildlife Refuge.

Management Opportunities, Needs, and Actions

- Beginning with the upstream and downstream fish passage facilities currently under development for the Prairie du Sac Dam, restore natural fish migration and movement patterns within the lower Wisconsin River system.
- Continue efforts to reestablish natural flow patterns within the lower Wisconsin River system through future Federal Energy Regulatory Commission (FERC) relicensing processes.
- Implement a Columbia County advisory group recommendation that the Portage levees gradually be disabled to allow for eventual floodplain restoration through the creation of a floodplain management district. Restore the floodplain of the Wisconsin River in the Central Sand Hills to floodplain forest, shrub swamp, sedge meadow, marsh, oak savanna, and grassland.
- Monitor population levels of endangered, threatened, and special concern indigenous species within the river systems of this ecological landscape such as weed shiner (*Notropis texanus*), least darter, banded killifish (*Fundulus diaphanus*), lake sturgeon, lake chubsucker (*Erimyzon sucetta*), and Blanchard's cricket frog (*Acris blanchardi*).
- Monitor the advancement and impacts of unwanted nonnative fauna and flora in the river.
- Maintain the natural flows of the lower Baraboo River, which is bordered by extensive Floodplain Forest known to contain rare plants and animals.
- The Montello River corridor occurs in a highly fragmented portion of the ecological landscape, yet it supports rare plants and has the potential to link important sites and to support sensitive animals. More inventory of this river system and its floodplain is needed for birds, herptiles, invertebrates, and plants.
- Sturgeon management has been very successful in the Fox River watershed downstream from the Central Sand Hills Ecological Landscape. Additional opportunities may exist for restoring sturgeon spawning habitat in the Upper Fox River basin in the Central Sand Hills, although positive results may depend upon modifying dams that block fish passage.
- Many miles of stream channels were modified for agriculture and navigation, and present opportunities for significant riparian habitat restoration. Existing Wisconsin DNR baseline stream surveys, conducted primarily by fishery management staff, should indicate which stream reaches would most likely benefit, or benefit the most, from channel improvements.

Lakes, Ponds, and Impoundments

Seepage lakes, drainage lakes, and ponds occur on glacial landforms such as pitted outwash, tunnel channels, and end moraines within the Central Sand Hills. However, oxbow lakes and cut-off meanders are treated as integral parts of the larger river corridors.

Deep kettle lakes, generally seepage lakes with good to fair water quality, are common in this ecological landscape. There are also a few turbid, shallow drainage lakes and impoundments along rivers. While these two types of lakes differ in their hydrology and habitat composition, they also share some similar challenges.

Seepage lakes here support populations of bass, panfish, and some northern pike. While most are impacted by aquatic invasive species such as Eurasian water-milfoil and curly-leaf pondweed, those with less speed boat activities tend to have more diverse aquatic plant communities and more limited distributions of invasive plants. However, these lakes tend to be desirable for lakefront home development and often lack tall, unmowed vegetation along the shoreline zone. There is a major opportunity on most of these lakes to restore buffers of unmowed native vegetation from the shoreline to at least 30 feet landward. This ***shoreland*** buffer intercepts excess nutrients and provides habitat for a wide range of shoreline amphibians and invertebrates, essential to ecological diversity and lake health.

Shallow lakes here are often eutrophic with high turbidity exacerbated by carp and wind stirring up sediments and nutrients from the lake bed. While some lakes such as Lake Puckaway do support extensive populations of panfish and sport fish such as northern pike, the nutrients cycled from sediment disturbance cause excessive blooms of algae, which can deplete oxygen levels to very low concentrations. Rough fish (carp) control has been implemented in Lake Puckaway with varying results. The extent to which carp control can improve water clarity and aquatic plant diversity has been documented in the Lake Wingra algae control project (in the Southeast Glacial Plains). Exclusion of carp from a limited area of Lake Wingra, a relatively shallow (16 feet) lake, led to a significant improvement in water clarity and quality. Intensive removal of carp from the lake further helped increase clarity and decrease nutrient resuspension and algae production. Some lakes in the Central Sand Hills have similar problems of nutrient overloading and rough fish dominance and could benefit from similar corrective measures and management.

The Prairie du Sac Dam has created Lake Wisconsin, a very large impoundment of 9,000 acres on the Wisconsin

River. This impoundment supports a portion of the middle Wisconsin River lake sturgeon population. Residents of the area have noted deterioration of water quality over the last several years, particularly in the form of severe blue-green algae blooms that completely deter swimming for most of the summer and also inhibit boating. These blooms cause many residents public health concerns for children and pets and often cause residents to stay indoors due to extremely foul odors. There are a number of likely point and nonpoint sources of excess nutrients contributing to this problem (WDNR 2010a).

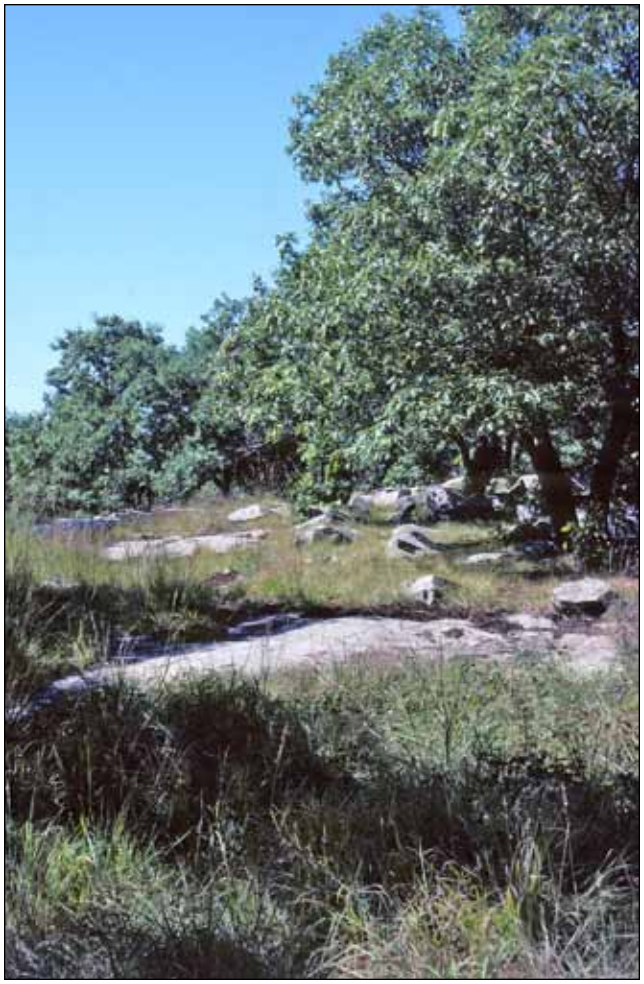
Both types of lakes in the Central Sand Hills Ecological Landscape suffer to varying degrees from inputs of excess sediments and phosphorus from agriculture and residential development. Lake health studies conducted in Waushara County and elsewhere have shown that, while many of the deeper seepage lakes still exhibit good water quality and mesotrophic conditions, nutrient levels are rising and water clarity is declining. Lake associations, in partnership with University of Wisconsin-Extension, and Wisconsin DNR, have an opportunity to mediate the decline in water quality by enlisting the cooperation of agricultural land and lakefront property owners. There are opportunities to develop lake and watershed plans to improve water quality and aquatic habitat in and near lakes, which will help improve fisheries and overall lake ecosystem ***resilience*** and, in shallow lakes, support more waterfowl. Properly designed sedimentation basins can capture more than 70% of soil particles that would otherwise wash into a lake. However, the greatest impact for protecting or improving water quality are achieved through improved land use practices, including fertilizer management, crop rotations, reduced tillage, and maintenance of vegetated buffers (GLCLCD 2004).

Management Opportunities, Needs, and Actions

- Protect hydrology and water quantity in areas of Portage and Waushara counties that may be susceptible to drawdown from high capacity wells. Local governments should work with Wisconsin DNR staff and Wisconsin Geological and Natural History Survey hydrologists to make certain that high capacity well permit conditions are sufficient to prevent stream and lake drawdowns that violate the Wisconsin DNR public trust responsibility.
- Reverse the impacts of development on lakes and shoreline habitats in stressed waterbodies, such as Silver Lake, Lake Wisconsin, and Big and Little Green lakes. Restore or enhance shoreline habitat by installing vegetated shoreline buffers that provide habitat necessary to support a diverse assemblage of aquatic and terrestrial plants and animals. If necessary, assess and improve efforts to inform landowners needing information on why and how to protect shoreline habitats and assist those who express an interest in improving their properties via conservation practices.
- Address excess agricultural nutrient and other pollutant-laden nonpoint runoff problems in watersheds identified through the ***Total Maximum Daily Load*** (TMDL) process and by citizen water quality monitoring. Investigate the potential use of sanitary district revenues and other funding sources to assist landowners with installing buffer strips, artificial wetlands, and other nutrient capture techniques that have been demonstrated to be effective. Watersheds providing flows into the Fox River, Lake Wisconsin, Lake Puckaway, and Big and Little Green lakes are prime candidates for attention.
- Maintain and enhance the current mix of multi-use recreational opportunities, including boating, sailing, angling, swimming, and enjoyment of scenic views throughout the Central Sand Hills, as one means of expanding the base of citizens who will advocate for improved water quality and wildlife habitat.
- Conduct surveys of undeveloped or lightly developed ponds and lakes that have the potential to harbor rare species and natural communities.
- Continue to implement the current Wisconsin DNR fisheries plan (Sims 2000, WDNR 2002) to address management issues for the aquatic resources in the portion of the river from the Kilbourn Dam at Wisconsin Dells to the Prairie du Sac Dam and all the way to the Mississippi River. See the management opportunities in the "Warmwater Rivers and Floodplain Corridors" section above for additional opportunities to better manage impoundments.
- Research is needed to clarify the impacts of the area's rapid population growth and the increasing human demands on aquatic resources, such as high quality, deep kettle lakes as well as more turbid shallow lakes.
- Management actions are needed to halt the decline in quality and fragmentation of aquatic habitats and to address groundwater contamination, with special concern regarding improperly abandoned wells.
- Encroachment of urban land uses onto farmland generally results in additional, harmful sediment and nutrient loading to surface waters and needs to be addressed in land use and water resources planning.

Bedrock Features

Bedrock outcroppings are not common in the Central Sand Hills, but they do provide unique habitat for a number of specialists. They also support "refugees" that can no longer dwell under the dense canopies and woody understories that now characterize many of the forests in this ecological landscape. The most prominent bedrock exposures are of Ordovician (St. Peter) sandstone and Precambrian igneous rocks such as rhyolite. Natural communities that are associated with the rock features include Bedrock Glade, talus slope, and Dry Cliff.



Bedrock Glade community on rhyolite bluff. Stunted oaks, prairie herbs, rock specialists. Pine Bluff, Green Lake County. Photo by Eric Epstein, Wisconsin DNR.

Management Opportunities, Needs, and Actions

- Identify and assess protection needs and opportunities for bedrock features in the Central Sand Hills Ecological Landscape.
- Identify actions that may threaten to damage or destroy bedrock features. Prioritize protection needs toward sites that contain good examples of bedrock communities, support populations of rare species, or are connected with other natural features of high value.
- Identify taxa associated with bedrock habitats and that could occur in central Wisconsin and design surveys to document their presence and distribution.
- More detailed inventory information is needed for selected taxa, especially vascular plants, nonvascular plants, invertebrates, and herptiles. This information would enable planners, managers, and others to better prioritize conservation projects focused on geologic features.

Miscellaneous Opportunities

Among the miscellaneous management opportunities here are scattered populations of rare species, smaller stream corridors, marshes and associated wetlands (especially those along streams and lakeshores), undeveloped lakes, and exceptional but scattered examples of all natural communities or habitats of high value to wildlife Species of Greatest Conservation Need.

Scattered state lands and a few federal Waterfowl Production Areas occur in the southern part of the ecological landscape and offer opportunities to manage for wetland communities, surrogate grasslands, and associated rare or declining species such as grassland birds and declining or at risk marsh species.

The southern end of the ecological landscape is complex (for example, four ecological landscapes come together in Dane County), and opportunities for management are highly constrained by high human population density, intensive land uses, and the absence of large blocks of public or single owner private lands. Opportunities to manage across ecological landscape boundaries may be especially important here to reduce some of the problems associated with small stand size and isolation within a matrix of heavily developed land.

Small, scattered tallgrass prairie remnants occur within the Central Sand Hills, and some of these are species rich and in good condition. A subset would make excellent, manageable conservation projects for local NGOs; others might be incorporated into existing public ownerships. Public-private partnerships will be critical to conserving these scattered and often isolated remnants.

Management Opportunities, Needs, and Actions

- Review the Fox River Headwaters Ecosystem document (Galvin et al. 2002) and develop priority actions to implement. Development partnerships among Wisconsin DNR programs, with other agencies, and with active NGOs as well as plan and conduct needed field inventories.
- Develop revised conservation priorities following the conclusion of updated and expanded inventories.
- Revisit Corning-Weeting Lakes (wetland complex) in northwest Columbia County to assess the current extent, composition, and condition of the conifer swamp here. When last examined in the 1970s, this wetland and seepage lake complex supported one of the Upper Midwest's southernmost sites for black spruce, and there is an urgent need for updated information.
- Examine Natural Heritage Inventory records for this ecological landscape, including the County Natural Area Inventories, to identify significant sites with high quality natural communities, aquatic features, and rare species populations that are not covered in the other "significant features" categories here.

- Inventories for some of the state-owned lands are being updated in conjunction with the development of new property master plans. In the future, such inventories need to be expanded in scope to enable better conservation decision-making by including lands and waters outside of existing property boundaries, and selected taxa.
- Shallow lakes and associated emergent marshes in the Central Sand Hills support and provide important habitat for rare resident and migratory birds.
- Design management projects to protect constellations of features, such as prairies, that now occur almost exclusively as small isolated remnants because of past loss of native vegetation, present ownership and development patterns, and the severe habitat fragmentation that now characterizes much of the Central Sand Hills Ecological Landscape.

Socioeconomic Characteristics

Socioeconomic information is summarized within county boundaries that approximate ecological landscapes unless specifically noted as being based on other factors. Economic data are available only on a political unit basis, generally with counties as the smallest unit. Demographic data are presented on a county approximation basis as well since they are often closely associated with economic data. The multi-county area used for the approximation of the Central Sand Hills Ecological Landscape is called the Central Sand Hills counties. The counties included are Portage, Waushara, Marquette, Green Lake, and Columbia because at least 25% of each county lies within the ecological landscape boundary (Figure 9.7).

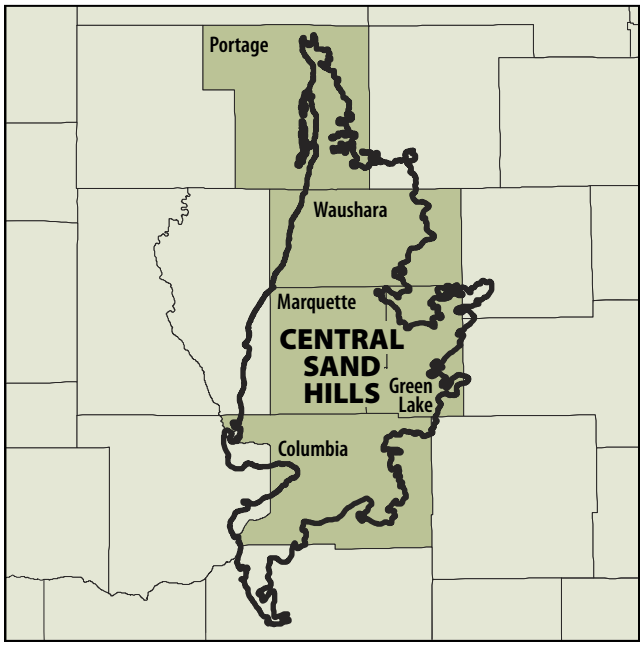


Figure 9.7. *Central Sand Hills counties.*

History of Human Settlement and Resource Use

American Indian Settlement

There is evidence of human presence in the Central Sand Hills at least as far back as the late Paleo-Indian stage, perhaps 9,000 years ago. The Pope site in southwestern Waupaca County produced large projectile points and unfinished tools and blanks characteristic of the technology of the late Paleo-Indian stage (Mason 1997). There is evidence in this ecological landscape that shows this area was inhabited more or less continuously from these early peoples all the way through Euro-American contact.

While there are not currently any tribal lands or significant American Indian populations in this area, a number of different tribes settled in this region during the Iroquois wars of the turbulent 17th century. Among these were the Sauk and Fox. While these two tribes are closely related and were joined in very close alliance after 1734, they are in fact separate and distinct cultures.

Euro-American Contact and Settlement

During the 17th century, French fur traders, soldiers, and missionaries began arriving in this region. As a result of Euro-American contact with American Indians, trading posts, missions, and forts along river routes and lakes were established. During the 1800s, however, American Indian tribes began ceding large areas of land to the government, and permanent Euro-American settlement began in earnest.

Among the first to arrive were Norwegians, settling in Portage and Waupaca counties in an area they called "Indilandet," or "Indian land" (The Wisconsin Cartographer's Guild 1998). Finns, Dutch, Polish, and Germans soon followed. By 1850 these ethnic groups were working a total of 1,165 farms in what would become the Central Sand Hills counties (ICPSR 2007). See the "Statewide Socioeconomic Assessments" section in Chapter 2, "Assessment of Current Conditions," for further discussion of the history of Euro-American settlement in central Wisconsin.

Early Agriculture

Permanent Euro-American settlement began in earnest in the Central Sand Hills counties in the 1840s and 1850s. In 1840 federal census estimates placed only 18 persons in Marquette County and 1,623 in Portage County (ICPSR 2007). By 1850 there were 20,039 people in Central Sand Hills counties but only about 1,165 farms, mostly in Columbia and Marquette counties. By 1860 the number of farms in Central Sand Hills counties had grown to 6,700 while the population had reached 61,614 people. Farm numbers continued to grow in Central Sand Hills counties, reaching 12,626 farms in 1900, then began to gradually decline thereafter (Figure 9.8). Meanwhile, populations in Central Sand Hills counties basically stayed the same after 1900, even as the population continued to grow statewide.

Farm numbers declined in the 1930s following the onset of the Great Depression (ICPSR 2007). Following World War II, farm numbers declined further as mechanization and urbanization combined to increase the average size of farms. That trend continued throughout much of the remaining 20th century. Farms were larger on average in Central Sand Hills counties than in the state as a whole, averaging 172 acres in 1950, compared to only 138 acres statewide (Figure 9.9).

Total value of all crops indicates the extreme influence of the Great Depression on agriculture. In 1910 all crops harvested in Central Sand Hills counties had an estimated total value of $9.9 million, which more than tripled by 1920 ($35.6 million) (ICPSR 2007). Total value of all crops in Central Sand Hills counties plummeted in 1930 ($16.8 million) and fell further in 1940 ($10.7 million). Total values of crops in Central Sand Hills counties comprised 6.4% of total value in the state in 1940. These crops came from farms comprising 7.3% of all Wisconsin farm acreage. Central Sand Hills counties' farms had been relatively productive before the Great Depression but fell behind thereafter, perhaps in part due to the impact of the drought in the 1930s on crops grown in the sandy soils found here.

Over the early part of the 20th century, the type of farming in Central Sand Hills counties underwent some fundamental shifts as Wisconsin became a national leader in the newly established dairy industry. The 1910 federal agricultural census listed "cereals" as 53.3% of the total value of all crops harvested in Central Sand Hills counties, but cereals comprised as little as 32.1% of total crop values in 1930, recovering only to 40.6% by 1940 (ICPSR 2007). Meanwhile, "hay and forage," associated with livestock farming, was only 19.3% of total value of crops harvested in Central Sand Hills counties in 1910 but had risen to 36% of total crop value by 1940. Nevertheless, Central Sand Hills counties had more diversified crop production than the state as a whole and produced proportionally less forage.

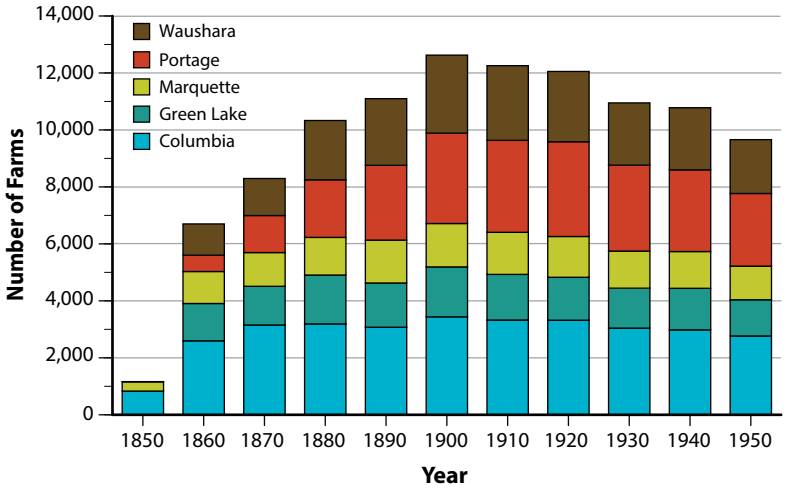


Figure 9.8. *Number of farms in Central Sand Hills counties between 1850 and 1950 (ICPSR 2007).*

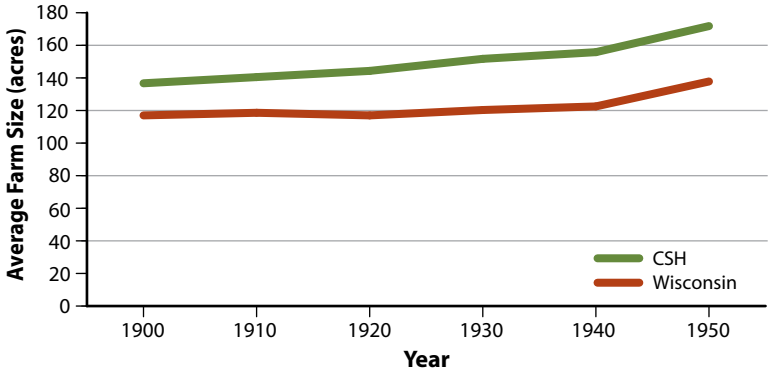


Figure 9.9. *Average farm size in Central Sand Hills counties between 1900 and 1950 (ICPSR 2007).*

Early Mining

Mining of lead, iron, and copper did not occur in the Central Sand Hills region of the state as it did in other areas of the state.

Early Transportation and Access

In the early 19th century, an extensive network of American Indian trails existed throughout the territory. These trails were widened into roads suitable for ox carts and wagons due to the rapid settlement growth during the 1830s (Davis 1947). A system of military roads was developed in Wisconsin in the 1820s and 1830s, connecting key cities and forts with one another. By 1870, however, the importance of railroads had caused these relatively primitive roadways to become of secondary value.

The Wisconsin Central rail line originally served this area of the state, connecting Menasha with Stevens Point and Stevens Point with Portage. Perhaps the most important line in the Central Sand Hills counties was the Soo Line. This line absorbed the Wisconsin Central in 1909 and became primarily a lumber, pulpwood, and mineral hauling line that served both northern Wisconsin and the paper mills on the lower Fox River (Nesbit 1973).

Early Logging Era

Stevens Point (just west of the Central Sand Hills boundary, in the Central Sand Plains Ecological Landscape) was one of the more important early sawmill centers in the state. The mill was built on the Wisconsin River, located close to the cutting areas to reduce the distance logs had to travel on the river (Ostergren and Vale 1997). The Stevens Point mill was not the only one in the area however; in 1831 Daniel Whitney built a mill near Plover, south of Stevens Point, and in 1836 Amable Grignon and Samuel Merrill built a mill near Port Edwards (Austin 1948).

Roth (1898) described forest conditions in some of the more heavily forested northern Wisconsin counties at the close of the 19th century. Roth reported heavy cutting in most of Portage County's forests, both pine and hardwoods, leaving expansive tracts of burned over pine slash. Only 20 million ***board feet*** of pine were estimated to remain standing, in isolated small pockets. Mixed hardwoods and eastern hemlock (*Tsuga canadensis*) stands totaled about 150 million board feet, about 50 million of which was eastern hemlock. Yet to be harvested, jack pine forests were extensive and heavily stocked, especially in southwest Portage County (note that southwestern Portage County is mostly within the Central Sand Plains Ecological Landscape). Roth (1898) estimated jack pine standing timber at 150 million board feet. By comparison, today there are 397 million board feet of pine, only 11 million board feet of eastern hemlock, 355 million board feet of hardwood, and only 25 million board feet of jack pine ***sawtimber*** in Portage County forests (USFS 2009). Columbia, Green Lake, Marquette, and Waushara counties were not part of Roth's survey.

Resource Characterization and Use[3]

The Central Sand Hills Ecological Landscape covers slightly over 2,000 square miles of land (this figure does not include areas of open water), or about 4% of the state (see Chapter 3, "Comparison of Ecological Landscapes," and/or the map of "WISCLAND Land Cover (1992) of the Central Sand Hills" in Appendix 9.K at the end of this chapter). With 79 square miles of surface water, this region ranks fifth (out of 16 ecological landscapes) in the percentage of area in surface water, with 84% of the surface water area in lakes.

Recreation is not well developed in this region. There is not as much forest or public land as in other ecological landscapes (e.g., those immediately to the north and west of the Central Sand Hills) and not as many visitors to state facilities.

Agriculture is important to the economy of the Central Sand Hills counties, which rank about average in terms of the percentage of land in agriculture as well as in net income per farmed acre. Compared to the rest of the state, a higher percentage of agricultural income comes from crops.

Forestry is also important as both timberland acreage and volume of ***growing stock*** have increased significantly in this ecological landscape. For instance, growing stock volume doubled in the last decade, and forest acreage has increased 23% (likely by conversion of old fields to forest, pine plantations, or small woodlots expanding enough to be considered forest by Forest Inventory and Analysis). However, the Central Sand Hills Ecological Landscape still ranks 11th out of 16 ecological landscapes in terms of the percentage of land that is forested.

[3]When statistics are based on geophysical boundaries (using GIS mapping), the name of the ecological landscape is followed by the term "ecological landscape." When statistics are based on county delineation, the name of the ecological landscape is followed by the term "counties."

The transportation infrastructure of the Central Sand Hills counties is somewhat less developed than the rest of the state. This region ranks 11th out of 16 ecological landscapes in railroad and airport densities. There are only five airports and no shipping ports.

The Central Sand Hills counties produce a significant amount of hydroelectric power (due to dams on the large rivers). Due to a fairly low acreage in forest, this ecological landscape does not produce much biomass, ranking 13th out of 16 ecological landscapes in the state in biomass production. There is one ethanol plan in Columbia County; there are no sited wind facilities in the ecological landscape.

The Land

Of the 1.3 million acres of land that make up the Central Sand Hills Ecological Landscape, 35% is forested (USFS 2009). About 92% of all forested land is privately owned while 7% belongs to the state, counties or municipalities, and 1% is federally owned.

Minerals

In 2007 there were 11 mining establishments in the five Central Sand Hills counties. Employment in Green Lake and Marquette counties totaled 56 people with wages of $3.2 million (WDWD 2009). Due to confidential disclosure rules, much of this information is limited to summary data.

Frac sand mining is increasing dramatically in some parts of Wisconsin due to greater use of certain sands in oil and gas extraction. As of December 2011, there were three frac sand mining or processing plants active or in development within the Central Sand Hills Ecological Landscape.

Water (Ground and Surface)

Water Supply

The data in this section are based on Wisconsin DNR's 24K Hydrography Geodatabase (WDNR 2015b), which are the same as the data reported in the "Hydrology" section; however, the data are categorized differently here so the numbers will differ slightly. Surface water covers 50,394 acres in the Central Sand Hills Ecological Landscape, or almost 4% of the total area. The 1,111 lakes (over 1 acre in size) add up to 42,352 acres, which is 84% of the surface water. There are five lakes over 1,000 acres in size. Three lakes, Green Lake, Lake Wisconsin (an impoundment), and Lake Puckaway are each over 5,000 acres. There are 138 impoundments, which overlap lakes, streams, and rivers acreage, covering 19,199 acres. There are 7,024 acres of streams and rivers, of which the Wisconsin and Fox rivers are the largest.

Water Use

Each day 239 million gallons of ground and surface water are withdrawn in the five Central Sand Hills counties (Table 9.3). About 18% of the withdrawals are from surface water. Of the 185,803 people that reside in these counties, 48% are served by public water sources, and 52% are served by private wells

(USGS 2010). The largest water usage, 63%, is for irrigation, with Portage and Waushara counties having the largest irrigation withdrawals, mostly from groundwater wells.

Recreation

Recreation Resources

Land use, land cover, water resources, and ownership patterns partly determine the types of recreation that are available to the public. For instance, in the Central Sand Hills Ecological Landscape, there is a higher percentage of grassland, wetland, and water compared to the rest of the state (see the "WISCLAND land cover (1992) of the Central Sand Hills" map in Appendix 9.K at the end of this chapter). There is less public land in general and fewer visitors to state lands (Wisconsin DNR unpublished data). Trail density is low compared to other ecological landscapes. Acreage in natural areas is lower than average as is the number of Land Legacy sites with high recreation potential.

Supply

Land and Water. There are approximately 473,000 acres of forestland in the Central Sand Hills Ecological Landscape, about 3% of the total acreage in the state (USFS 2009; see Chapter 3, "Comparison of Ecological Landscapes"). In addition, there are 50,394 acres of water, or 4% of the total water acreage in the state. Streams and rivers make up only 14% of the surface water, and lakes and reservoirs make up over 86%. Important recreational waters include the Wisconsin River, the Fox River, Lake Wisconsin, Green Lake, and Lake Puckaway (WDNR 2015b).

Public Lands. Public access to recreational lands is vital to many types of recreational activity. In the Central Sand Hills Ecological Landscape, almost 127,600 acres, or 9.2% of all land and water, is publicly owned (WDNR 2007b). This is significantly lower than the statewide average of 19.5% and ranks this ecological landscape 10th out of 16 ecological landscapes in the proportion of public ownership. There are about 50,400 acres of public waters, 76,300 acres of state recreational lands, 722 acres of federal land, and about 200 acres of county forest and natural areas.

State-owned lands and facilities are especially important to recreation in the Central Sand Hills Ecological Landscape. Although there is no state forest in this ecological landscape, there are approximately 1,270 acres in state parks and recreation areas, 7,204 acres in state natural areas, 120 acres of state trails, 370 acres of wild rivers, and 70,566 acres in wildlife and fisheries management lands (WDNR 2007b). The largest state parks include portions of Devils Lake State Park and Hartman Creek State Park. The Mecan River Fishery Area, the Grand River Marsh Wildlife Area, and the Pine Island Wildlife Area total over 5,000 acres each, and there is a small portion of the Lower Wisconsin State Riverway in this ecological landscape.

Trails. Although the Central Sand Hills counties have over 1,200 miles of recreational trails (Table 9.4), they rank 14th out of 16 ecological landscapes in trail density (miles of trail per square mile of land). There is a lower density of hiking, biking, ATV, and cross-country ski trails compared to the rest of the state (Wisconsin DNR unpublished data).

Table 9.3. *Water use (millions of gallons/day) in the Central Sand Hills counties.*

County	Ground-water	Surface water	Public supply	Domestic[a]	Agriculture[b]	Irrigation	Industrial	Mining	Thermo-electric	Total
Columbia	9.9	18.3	3.4	1.3	1.4	1.7	1.6	0.3	19.0	28.7
Green Lake	8.6	0.8	1.3	0.5	2.4	2.7	1.0	1.6	–	9.5
Marquette	9.9	0.5	0.2	0.7	4.3	4.8	0.5	–	–	10.5
Portage	116.9	22.2	9.9	1.7	1.3	92.5	26.2	0.6	7.0	139.2
Waushara	51.7	0.3	0.7	0.8	1.2	49.1	0.2	0.0	–	52.0
Total	**197.0**	**42.1**	**15.5**	**5.0**	**10.6**	**150.8**	**29.5**	**2.5**	**26.0**	**239.9**
Percent of total	**82%**	**18%**	**6%**	**2%**	**4%**	**63%**	**12%**	**1%**	**11%**	

Source: Based on 2005 data from the U.S. Geological survey on water uses in Wisconsin counties (USGS 2010).
[a]Domestic self-supply wells.
[b]Includes aquaculture and water for livestock.

Table 9.4. *Miles of trails and trail density in the Central Sand Hills counties compared to the whole state.*

Trail type	Central Sand Hills (miles)	Central Sand Hills (miles/100 mi^2)	Wisconsin (miles/100 mi^2)
Hiking	67	2.2	2.8
Road biking	72	2.4	4.8
Mountain biking	29	1.0	1.9
ATV: summer & winter	–	–	9.3
Cross-country skiing	126	4.2	7.2
Snowmobile	936	31.2	31.2

Source: Wisconsin DNR unpublished data.

Campgrounds. Camping is a favorite recreational activity in the Central Sand Hills counties where there are 82 public and privately owned campgrounds providing about 8,114 campsites (Wisconsin DNR unpublished data). With 5% of the state's campgrounds, this ecological landscape ranks ninth out of 16 ecological landscapes in terms of the number of campgrounds and 4th in campground density (campgrounds per square mile of land).

Land Legacy Sites. The Wisconsin Land Legacy project has identified over 300 places of significant recreational and ecological importance in Wisconsin, and 14 are either partially or totally located within the Central Sand Hills Ecological Landscape (WDNR 2006b). The Portage to Buffalo Lake Corridor is considered to have the highest recreational potential. In addition, four legacy sites were identified as having the highest conservation potential: the Badger Army Ammunition Plant, the Middle Wisconsin River, the Montello Area Coastal Plain Marshes, and the Oxford Savanna.

State Natural Areas. In addition, there are 7,204 acres of state natural areas (either partially or totally located within the Central Sand Hills Ecological Landscape) of which 86% is publicly owned (including government and educational institutions), and 14% is owned by private interests (including NGOs) (Wisconsin DNR unpublished data). The largest state natural areas in this ecological landscape include Pine Island Savanna (798 acres; Columbia and Sauk counties), Comstock Bog-Meadow (657 acres; Marquette County), Page Creek Marsh (576 acres; Marquette County), Lunch Creek Wetlands (567 acres; Waushara County), and Rocky Run Oak Savanna (455 acres; Columbia County). For more information on Wisconsin state natural areas, see the Wisconsin DNR website (WDNR 2015e).

Demand

Fishing and Hunting License Sales. Of all license sales, the highest revenue producers for the Central Sand Hills counties were resident hunting licenses (48% of total sales), resident fishing licenses (27% of total sales), and nonresident fishing licenses (14% of total sales) (Wisconsin DNR unpublished data). Table 9.5 shows a breakdown of various licenses sold in the Central Sand Hills counties. Portage County sells the most licenses and brings in the most revenue. This ecological landscape county approximation accounts for about 3% of total license sales in the state. However, persons buying licenses in the Central Sand Hills counties may travel to other parts of the state to use them.

Metropolitan Versus Nonmetropolitan Recreation Counties. A research study by Johnson and Beale (2002) classified Wisconsin counties according to their dominant characteristics. One classification, "nonmetro recreation county," is characterized by high levels of tourism, recreation, entertainment, and seasonal housing. There are 21 nonmetro counties in Wisconsin. Four of the five Central Sand Hills counties are classified as nonmetro recreation: Columbia, Green Lake, Marquette, and Waushara counties.

Recreational Issues

Results of a statewide survey of Wisconsin residents indicated that a number of current issues are affecting outdoor recreation opportunities within Wisconsin (WDNR 2006a). Many of these issues, such as increasing ATV usage, overcrowding, increasing multiple-use recreation conflicts, loss of public access to lands and waters, invasive species, and poor water quality, are common across many regions of the state.

Silent Sports Versus Motorized Sports. Over the next decade, the most dominant recreation management issues will likely revolve around conflicts between motorized and nonmotorized recreation interests. From a silent-sport perspective, noise pollution from motorized users is one of the higher causes for recreation conflict (WDNR 2006a). Recreational motorized vehicles include snowmobiles, ATVs, motor boats, and jet skis. ATV use is especially contentious. ATV riding has been one of the fastest growing outdoor recreational activities in Wisconsin. Many ATV riders feel there is a distinct lack of ATV trails and are looking primarily to public lands for places to expand their riding opportunities.

Timber Harvesting. A high percentage of statewide residents are concerned about timber harvesting in areas where they recreate (WDNR 2006a). Their greatest concern about timber

Table 9.5. *Fishing and hunting licenses and stamps sold in the Central Sand Hills counties.*

County	Resident fishing	Nonresident fishing	Misc. fishing	Resident hunting	Nonresident hunting	Stamps	Total
Columbia	9,532	3,033	760	14,656	274	4,043	32,298
Green Lake	4,974	3,375	394	7,165	124	2,919	18,951
Marquette	6,182	2,937	235	7,011	281	2,079	18,725
Portage	16,109	1,355	433	24,271	397	7,328	49,893
Waushara	5,241	1,242	283	7,731	138	2,283	16,918
Total	**42,038**	**11,942**	**2,105**	**60,834**	**1,214**	**18,652**	**136,785**
Sales	**$958,471**	**$484,595**	**$44,193**	**$1,692,782**	**$172,821**	**$149,065**	**$3,501,927**

Source: Wisconsin DNR unpublished data, 2007.

harvesting is large-scale visual changes (e.g., large openings) in the forest landscape. Forest thinning and harvesting that creates small openings is more acceptable. Silent-sport enthusiasts as a group are the most concerned about the visual impacts of harvesting, while hunters and motorized users are somewhat less concerned.

Loss of Access to Lands and Waters. With the ever-increasing development along shoreline properties and continued parcelization of lands near water, there has been a loss of readily available access to lands and waters within the Central Sand Hills Ecological Landscape. Another element that may play into the perception of reduced access is a lack of information about where to go for recreational opportunities. This element was highly ranked as a barrier to increased outdoor recreation in a statewide survey (WDNR 2006a).

Agriculture

Farm numbers in the Central Sand Hills counties decreased 30% from 1970 to 2002 (USDA NASS 2004). There were approximately 6,790 farms in 1970 and 4,734 in 2002. Between 1970 and 2002, average farm size increased from 201 acres to 239 acres, much higher than the statewide average of 204 acres. The overall land in farms has steadily decreased since the 1970s (Figure 9.10). In 1970 there were about 1.4 million acres of farmland, and by 2002 the acreage was down to 1.1 million acres, a decrease of 17%.

Agriculture is fairly important to the economy of the Central Sand Hills counties. The five Central Sand Hills counties have between 47% and 68% of their land area in farms. Columbia and Green Lake counties have the highest percentage.

In 2002 net cash farm income totaled $94 million, or $83 per agricultural acre, lower than the statewide average of $91 per acre (USDA NASS 2004). Also, in 2002 the market value of all agriculture products sold in the Central Sand Hills counties was $413 million (5% of state total); 61% of this amount came from crop sales (compared to an average 36% statewide), while the remaining 39% was from livestock sales (compared to an average 64% statewide). Portage and Waushara counties received some of the highest returns for crop production in the state.

In 2007, 8,558 acres of farmland had been sold, of which 92% stayed in agricultural use at an average selling price of $3,558, and 8% was diverted to other uses at an average sale price of $7,709 per acre (USDA NASS 2009). Central Sand Hills counties have some of the lowest diversion rates in the state.

Timber

Timber Supply

Based on 2007 U.S. Forest Service Forest Inventory and Analysis (FIA) data (USFS 2009), 35% (472,936 acres) of the total land area for the Central Sand Hills Ecological Landscape is forested. This is only 2.9% of Wisconsin's total forestland acreage. Forestland is defined by FIA as any land with more than 17% canopy cover.

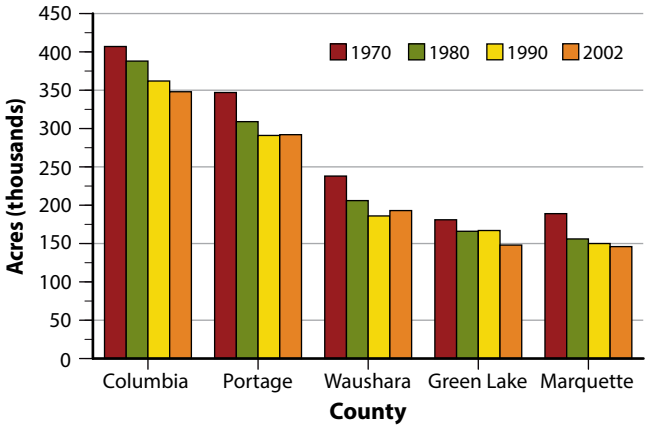


Figure 9.10. *Acres of farmland in the Central Sand Hills counties by county and year (USDA NASS 2004).*

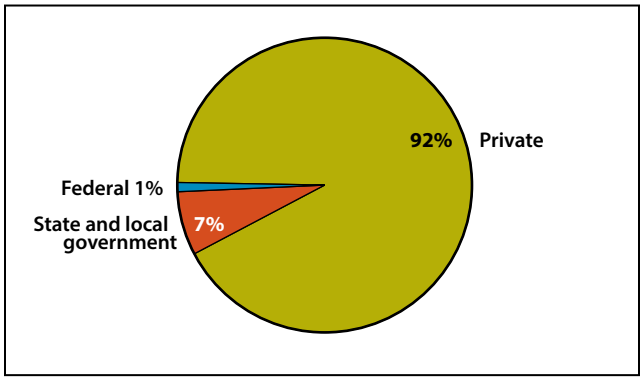


Figure 9.11. *Timberland ownership in the Central Sand Hills Ecological Landscape (USFS 2009).*

Timber Ownership. ***Timberland*** is defined as forestland capable of producing 20 cubic feet of industrial wood per acre per year that is not withdrawn from timber utilization. In the Central Sand Hills Ecological Landscape, about 92% of all forested land is privately owned while 7% belongs to the state, counties, or municipalities, and 1% is federally owned (USFS 2009; Figure 9.11).

Growing Stock and Sawtimber Volume. There was approximately 659 million cubic feet of growing stock volume in the Central Sand Hills Ecological Landscape in 2007, or 3% of total volume in the state (USFS 2009). Most of this volume, 61%, was in hardwoods, less than the proportion of hardwoods statewide, which was 74% of total growing stock volume. Hardwoods made up a lower proportion, 55%, of sawtimber volume in the Central Sand Hills Ecological Landscape. In comparison, the proportion of hardwood sawtimber statewide was 67% of total volume.

Annual Growing Stock and Sawtimber Growth. Between 1996 and 2007, the timber resource in the Central Sand Hills Ecological Landscape increased by 237 million cubic feet, or 56% (USFS 2009). Approximately 55% of this increase

occurred in hardwood volume. Sawtimber volume increased by 1.1 billion board feet, or 98% during this period. Most of this change, 57%, occurred in softwood volume and may have been partly a result of an increase in timberland acreage between 1996 and 2007, from 384,402 to 472,936 acres, or 23% (likely by conversion of old fields to forest, pine plantations, or small woodlots expanding enough to be considered forest by Forest Inventory and Analysis). Statewide, timberland acreage increased by only 3% during the same time period.

Timber Forest Types. According to FIA data, the predominant forest type groups (see Appendix H, "Forest Types That Were Combined into Forest Type Groups Based on Forest Inventory and Analysis (FIA) Data" in Part 3, "Supporting Materials") in terms of acreage are oak-hickory (46%) and eastern white, red, and jack pine (20%), with smaller amounts of bottomland hardwoods, aspen-birch, and maple-basswood (USFS 2009). Acreage is predominantly in the sawtimber size class (58%) with much less in the pole size class (27%) and only 12% in seedling and sapling classes (Table 9.6).

Table 9.6. *Acreage of timberland in the Central Sand Hills Ecological Landscape by forest type and stand size.*

Forest type[a]	Seedling/sapling	Pole-size	Sawtimber	Total
White oak-red oak-hickory	7,081	32,454	77,752	117,286
Red pine	1,338	9,783	55,319	66,440
White oak	–	3,898	34,237	38,135
Sugarberry-hackberry-elm-green ash	9,479	6,394	6,033	21,906
Aspen	5,000	6,779	5,416	17,195
Eastern white pine	1,055	–	15,301	16,356
Northern red oak	4,124	710	11,267	16,100
Post oak-blackjack oak	482	1,926	13,519	15,927
Chestnut oak-black oak-scarlet oak	–	4,517	10,858	15,375
White birch	1,688	12,675	978	15,342
Tamarack	5,223	6,323	2,632	14,178
Jack pine	5,671	2,707	5,181	13,560
Sycamore-pecan-American elm	–	6,704	6,079	12,783
Black ash-American elm-red maple	–	4,874	6,378	11,252
Exotic softwoods & hardwoods				10,874
Black cherry	9,894	–	–	9,894
Other pine-hardwood	–	2,624	6,458	9,082
Mixed upland hardwoods	–	4,482	3,763	8,245
Elm-ash-locust	122	6,443	–	6,565
Nonstocked[b]				6,263
Willow	4,376	–	–	4,376
Hard maple-basswood	–	–	4,024	4,024
Sugar maple-beech-yellow birch	–	3,932	–	3,932
Black locust	–	2,396	877	3,273
White spruce	2,694	–	–	2,694
Eastern redcedar-hardwood	–	2,573	–	2,573
Bur oak	–	510	1,990	2,500
Cottonwood	–	–	1,929	1,929
Red maple-oak	–	1,331	–	1,331
Silver maple-American elm	–	–	1,285	1,285
River birch-sycamore	–	694	–	694
Cherry-ash-yellow-poplar	–	–	643	643
White pine-red oak-white ash	–	607	–	607
Red maple-upland	–	–	315	315
Total	**58,227**	**125,336**	**272,236**	**472,936**

Source: U.S. Forest Service Forest Inventory and Analysis (FIA) Mapmaker (USFS 2009).

[a]U.S. Forest Service Forest Inventory and Analysis (FIA) uses a national forest typing system to classify FIA forest types from plot and tree list samples. Because FIA is a national program, some of the national forest types in the above table do not exactly represent forest types that occur in Wisconsin. For example, neither post oak nor blackjack oak occur to any great extent in Wisconsin, but since there is no "black oak forest type" in the FIA system, black oak stands in Wisconsin were placed in the "post oak-blackjack oak" category in this table.

[b]Nonstocked land is less than 16.7% stocked with trees and not categorized as to forest type or size class.

Timber Demand

Removals from Growing Stock. The Central Sand Hills Ecological Landscape has about 3.2% of the total growing stock volume on timberland in Wisconsin (USFS 2009). Average annual removals from growing stock for the ecological landscape were 15 million cubic feet, or about 2.3% of total statewide removals (349 million cubic feet) between 2002 and 2007. (See the "Socioeconomic Characteristics" section in Chapter 3, "Comparison of Ecological Landscapes.") Average annual removals to growth ratios vary by species (only major species shown), as can be seen in Figure 9.12. Removals exceed growth for quaking aspen, northern red oak, and black walnut.

Removals from Sawtimber. The Central Sand Hills Ecological Landscape has about 3.8% of the total sawtimber volume on timberland in Wisconsin (USFS 2009). Average annual removals from sawtimber for the ecological landscape were about 48 million board feet, or 4.6% of total statewide removals (1.1 billion board feet) between 2002 and 2007. Average annual removals to growth ratios vary by species, as can be seen in Figure 9.13 (only major species shown). Sawtimber removals exceeded growth for quaking aspen, northern red oak, black walnut, and black locust.

Price Trends

In the Central Sand Hills counties, black cherry, northern red oak, and white oak were the highest priced hardwood sawtimber species in 2007 (WDNR 2008a). Northern white-cedar (*Thuja occidentalis*), red pine, and eastern white pine were the most expensive softwood timber species. Sawtimber prices for the year 2007 were generally lower for softwoods and hardwoods compared to the rest of the state, according to ***stumpage*** rates calculated for the ***Managed Forest Law*** program.

For pulpwood, jack pine was the most valuable. Pulpwood values in the Central Sand Hills counties were slightly lower for softwoods and higher for hardwoods than the statewide average, according to stumpage rates calculated for the Managed Forest Law program (WDNR 2008a).

Infrastructure

Transportation

The transportation infrastructure of the Central Sand Hills Ecological Landscape is somewhat less developed than in the rest of the state. For instance, road mile density is about the same, but railroad density is 23% lower, and airport runway density is 24% lower than for the state as a whole (Table 9.7). There are five airports in the Central Sand Hills Ecological Landscape but no shipping ports.

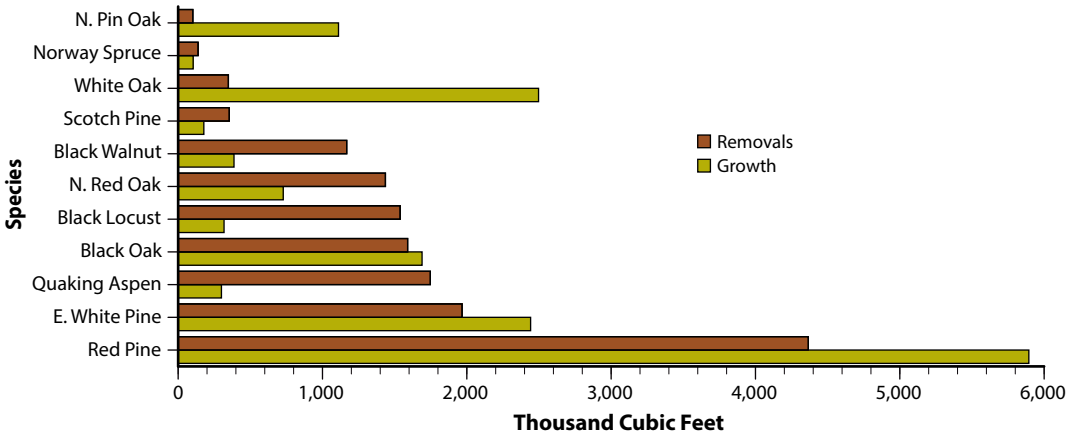


Figure 9.12. *Growing stock growth and removals (selected species) on timberland in the Central Sand Hills Ecological Landscape (USFS 2009).*

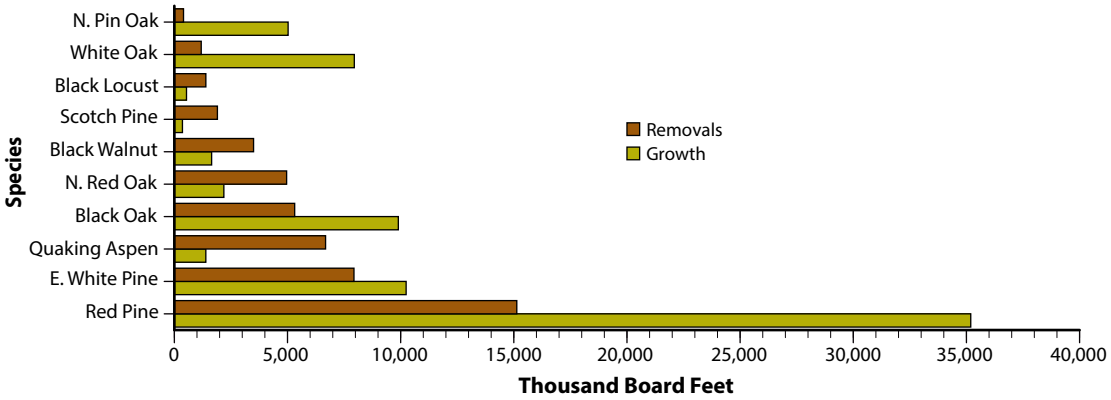


Figure 9.13. *Sawtimber growth and removals (selected species) on timberland in the Central Sand Hills Ecological Landscape (USFS 2009).*

Table 9.7. *Road miles and density, railroad miles and density, number of airports, airport runway miles and density, and number of ports in the Central Sand Hills Ecological Landscape.*

	Central Sand Hills	State total	% of state total
Total road length (miles)[a]	7,270	185,487	4%
Road density[b]	3.5	3.4	–
Miles of railroads	156	5,232	3%
Railroad density[c]	7.5	9.7	–
Airports	5	128	4%
Miles of runway	2.8	95.7	3%
Runway density[d]	1.3	1.8	–
Total land area (square miles)	2,091	54,087	4%
Number of ports[e]	–	14	0%

[a]Includes primary and secondary highways, roads, and urban streets.
[b]Miles of road per square mile of land. Data from Wisconsin Roads 2000 TIGER line files (data set) (WDOT 2000).
[c]Miles of railroad per 100 square miles of land. Data from 1:100,000-scale Rails Chain Database (WDOT 1998).
[d]Miles of airport runway per 1,000 square miles of land. Data from Wisconsin Airport Directory 2009–2010 web page (WDOT 2010).
[e]Data from Wisconsin Commercial Ports Association (WCPA 2010).

Renewable Energy

Hydroelectric and wind turbine power are the only renewable energy sources quantified by county in Wisconsin energy statistic produced by the Wisconsin Department of Administration (WDOA 2006). Some general inferences can be drawn from other sources regarding the potential for renewable energy production in the Central Sand Hills counties, especially for woody biomass, corn-based ethanol, and wind power.

Biomass. Woody biomass is Wisconsin's most-used renewable energy resource, but the Central Sand Hills Ecological Landscape produces only 22.1 million oven-dry tons of biomass, or 2.2% of total production in Wisconsin (USFS 2009). Approximately 35% of the land base is forested, but acreage in forests increased by 23% in the last decade.

Hydroelectric. There are two hydroelectric power plants in Columbia County that generate 50.2 million kilowatt hours (kWh), or 3.5% of hydroelectric power in the state (WDOA 2006). In the entire state, there are 68 sites, owned either by utility companies or privately owned, which generate a total of 1,462 million kilowatt hours.

Ethanol. The Central Sand Hills counties produced 32.7 million bushels of corn in 2002, or 5.5% of total production in the state (USDA NASS 2004). Acreage in agriculture made use of 57% of the land base (some woodland is counted as agriculture by this source) in the Central Sand Hills counties but decreased by 17% between 1970 and 2002. There are two ethanol plants located in in Columbia County (Renewable Fuels Association 2014).

Wind. There are currently no sited or proposed wind facilities in the Central Sand Hills Ecological Landscape (WWIC 2014). Mean annual power densities are generally between 100 and 300 W/m^2 (watts per square meter) in this part of the state, indicating that there is potential for wind generation in certain areas (USDE 2014).

Current Socioeconomic Conditions

Central Sand Hills counties are primarily rural in character, with several small cities and towns. The exception is Portage County, which has a younger population with a higher education attainment level than other Central Sand Hills counties. Population density and housing density are typical of rural Wisconsin counties. Property values are lower than the statewide average but comparable to many rural Wisconsin counties. In general, the Central Sand Hills counties are homogenous in racial structure and exhibit an age distribution skewed towards an older population. Education attainment in Central Sand Hills counties is lower than statewide averages. Housing growth has generally exceeded population growth in Central Sand Hills counties and has been steadier than locally sporadic population growth.

Demography

Population Distribution

The U.S. Census Bureau estimated the combined population of the Central Sand Hills counties in 2010 to be 185,803, a little more than 3% of the state's population (USCB 2012a). These counties were classified as mostly rural by the U.S. Census Bureau but to varying degrees among the Central Sand Hills counties. Marquette County (15,404 estimated population in 2010), and Waushara County (24,496 estimated population in 2010) were classified as entirely rural. Portage County (38.2%) had a rural proportion much closer to statewide rural composition (31.7%) and contained roughly one third of the total population of Central Sand Hills counties (USCB 2009). However, Portage County was less representative of the ecological landscape as a whole than were the more rural counties.

According to U.S. Census Bureau estimates, population centers (defined by the U.S. Census Bureau as cities with population over 2,500) within the Central Sand Hills counties include the cities of Stevens Point (population 24,849), Portage (9,802), Berlin (5,109), Columbus (4,971) and Lodi (2,932) (USCB 2009). Stevens Point in Portage County and Columbus in Columbia County are actually outside the geographic boundaries of the ecological landscape but are included as part of the Central Sand Hills counties. Though these cities are outside the Central Sand Hills Ecological Landscape boundaries, their economic influence is considerable since local economies rely heavily on nearby cities with associated markets and opportunities. However, their influence (particularly in demographic terms) slightly skews the analyses that follows.

Population Density

The mean population density in 2010 of the Central Sand Hills counties (62 persons per square mile) was less than that of the state as a whole (105). Population density in more populous Portage County (87.4) was much higher than in the rest of Central Sand Hills counties, which ranged from a low in Marquette County (33.8 persons per square mile) to a high in Columbia County (74.2) (USCB 2012a).

Population Structure

Age. Among Central Sand Hills counties, age distribution is clearly divided between relatively young Portage County (median age of 33 years old) and the remaining Central Sand Hills counties, which have median ages ranging from 38 years old in Columbia County to the high of 42 years old in Waushara County. As a whole, Central Sand Hills counties have a higher median age than statewide (36 years old) (USCB 2009).

Age distribution of Central Sand Hills counties' residents have a slightly greater proportion of the population that is older than 65 years of age and slightly less young people than the state as a whole in 2010 (USCB 2012a). Generally, Portage County has a relatively young population, skewed by the inclusion of Stevens Point, while the remaining Central Sand Hills counties all have relatively older population distributions more representative of the five counties as a whole. Central Sand Hills counties' population of people under 18 years of age (21.6% of total population in 2010) was slightly lower than statewide (23.6%). Among Central Sand Hills counties, Waushara County had the lowest percentage of its population under 18 (19.7%). The remaining Central Sand Hills counties also had relatively low populations under 18 years (all below 23.3%). Central Sand Hills counties combined had 15.6% of their population aged greater than 65 years of age, greater than the statewide average (13.7%). Individual Central Sand Hills counties were similarly varied in their percentage of people 65 and older: Marquette County (21.1% of its population is 65 or older), Waushara County (19.9%), and Green Lake County (19.2%) had among the highest percentage of people over 65 years of age in the state, while only 12.8% of residents in Portage County were 65 or older.

Minorities. The area is racially homogeneous (as defined by U.S. Census reports for 2010 data) with a 95.1% white, non-Hispanic population compared to 86.2% statewide (USCB 2012a). Only 3.1% of Central Sand Hills counties' population is Hispanic, compared to 5.9% statewide. No other ethnic group comprises more than 1% of the Central Sand Hills counties' population.

Education. In terms of percentage of residents 25 years old or older who have graduated from high school in the Central Sand Hills counties, Columbia (90.6%) and Portage (90.4%) counties exceed the statewide average (89.4%), according to the 2010 federal census (USCB 2012a). The remaining Central Sand Hills counties are clustered among counties with lower high school graduation rates, including Green Lake (87.0%), Marquette (85.6%), and Waushara (84.4%) counties. Central Sand Hills counties also have lower levels in attaining higher education; 20.4% of residents 25 or older have graduated from college or higher, compared to 25.8% statewide. Only Portage County (27.1%) exceeds the statewide average for attainment of bachelor's or higher degrees. All other Central Sand Hills counties fall below statewide higher education attainment, ranging from Columbia County (19.9%) to the fourth-lowest ranking county statewide: Marquette County (12.8%).

Population Trends

Over the extended period from 1950 to 2006, Central Sand Hills counties' combined population grew at a slightly faster rate (71% population growth) than has the state's population (62%) (USCB 2009). Over the course of the last half of the 20th century, more populated Portage County grew ahead of the statewide pace early but slowed in recent decades as manufacturing jobs slowed. Population growth patterns in Waushara and Columbia counties had the opposite pattern, growing faster in recent decades. Marquette County's population grew at highly sporadic rates from decade to decade. Green Lake County experienced the least growth (27.6%) among all Central Sand Hills counties from 1950 to 2006.

All Central Sand Hills counties' populations grew more slowly than the statewide population in the 1950s. Portage County (28.6% population growth) was the only Central Sand Hills county to exceed statewide population growth (11.8%) in the 1960s (USCB 2009). Much of the Central Sand Hills counties' combined population growth occurred in the decade from 1970 to 1980, when Marquette County grew 31.7%. Each of the Central Sand Hills counties grew at a faster rate than the state (6.5%), and Central Sand Hills counties combined grew at a rate of 16.4%. From 1980 to 1990, population growth in Central Sand Hills counties slowed to 5.1%, although still higher than 4% population growth statewide. From 1990 to 2000, population growth in Central Sand Hills counties (13.3%) surged along with statewide growth

(9.6%), with the greatest growth occurring in Marquette (28.5%) and Waushara (19.4%) counties. From 2000 to 2006, population growth in Central Sand Hills counties combined slowed (2%) compared to statewide growth (4%), as relatively populous Portage County grew at only 1%, and Marquette (-5%) and Green Lake (-1.5%) counties actually experienced population loss.

Housing

Housing Density. The Central Sand Hills counties' combined housing density in 2010 (30.5 housing units per square mile) was less than the state's housing density (48.5) (USCB 2012b). Similar to population density measures, Central Sand Hills counties' housing density was highest in Portage County (37.5 housing units per square mile) and lowest in Marquette County (21.7). The remaining Central Sand Hills counties had moderately low housing densities ranging from 34.1 housing units per square mile in Columbia County to 23.7 housing units per square mile in Waushara County.

Seasonal Homes. Seasonal and recreational homes comprised 11.0% of housing stock in the Central Sand Hills counties in 2010, higher than the statewide average of 6.3% (USCB 2012c). Prevalence of seasonal homes is highly variable in the Central Sand Hills counties; Waushara County (25.0% of all housing) and Marquette County (24.5%) have an abundance of seasonal homes as does Green Lake County (18.8%) to a lesser degree. This indicates relative prominence of tourism and seasonal residents in these counties. The most populous Central Sand Hills counties, Portage (2.2%) and Columbia (5.7%), have much lower percentages of seasonal housing.

Housing Growth. Housing growth in Central Sand Hills counties combined generally lagged behind the state in the middle part of the 20th century, then surged ahead of statewide levels from 1970 to 1990 and has since gradually fallen below statewide housing growth (USCB 2009). From 2000 to 2007, housing growth in Central Sand Hills counties (9.6%) was slightly less than statewide growth (10.3%). The most rapid housing growth occurred between 1970 and 1980 when the number of houses in Central Sand Hills counties grew by 37.3% (compared to 30.3% statewide), and Marquette, Portage, and Waushara counties all enjoyed housing growth just under 50%. Relatively high housing growth continued in Central Sand Hills counties (18.9%) from 1980 to 1990, compared to statewide (14.9%). Among Central Sand Hills counties, only Green Lake County has consistently lagged behind statewide housing growth over time. Patterns in other Central Sand Hills counties have generally reflected population growth dynamics, though housing growth in areas with much seasonal housing (e.g., Marquette and Waushara counties) has outpaced population growth.

Housing Values. Housing values in 2010 were lower throughout most of the Central Sand Hills counties compared to the statewide median ($166,100), with only moderate variation among the five counties (USCB 2012a). Columbia County was the only Central Sand Hills county with a relatively high median housing value ($173,100), likely driven by its proximity to Dane County and the state capital of Madison to the south. The remaining Central Sand Hills counties had median housing values ranging from $140,800 in Portage County to $133,600 in Waushara County.

The Economy

The economy of the Central Sand Hills counties is characterized by significantly less economic activity than other regions of the state. All measures of personal income are comparatively low in the Central Sand Hills counties, but unemployment is only slightly above the statewide average and poverty levels are relatively low. Property values vary among the Central Sand Hills counties, depending largely on relative prevalence of recreational properties. Agriculture remains an important part of the local economy, but most growth appears to be occurring in tourism-related, manufacturing, and finance and insurance sectors. Portage and Columbia counties fare the best in terms of economic activity, while more remote Green Lake, Marquette and Waushara counties are growing as recreation centers.

Income

Per Capita Income. Total personal income for the five Central Sand Hills counties in 2006 was $5.58 billion (2.9% of the state total) (USDC BEA 2006). The majority of income was found in the most populous Central Sand Hills counties: Portage ($2.08 billion) and Columbia ($1.91 billion). Combined per capita income in Central Sand Hills counties in 2006 ($30,777) was lower than the statewide average of $34,405 (Table 9.8), with only Columbia County ($34,796) matching statewide figures. Per capita incomes in Waushara ($24,639) and Marquette ($25,297) counties were among the lowest in the state.

Household Income. Median household income levels in Central Sand Hills counties in 2005 were generally lower than the statewide average ($47,141). Columbia County ($51,652) had relatively high median household income. Portage County ($47,140) approximated the statewide average, while median household income in the rest of the Central Sand Hills counties was relatively low. Though data limitations prevent using a Central Sand Hills-wide average for household income, Central Sand Hills counties generally ranked slightly higher statewide in terms of median household income than they do for per capita income (USCB 2009).

Earnings Per Job. Earnings per job in the five Central Sand Hills counties combined ($30,121) in 2006 were lower than the state average ($36,142) (USDC BEA 2006). Wages per job figures among Central Sand Hills counties were highest in Portage ($31,575) and lowest in Waushara ($25,636) counties.

Unemployment

The Central Sand Hills counties combined had a 2006 unemployment rate of 4.9%, slightly higher than the statewide average (4.7%). Portage (4.5%) and Columbia (4.7%) counties compared favorably to statewide unemployment rates (USDL BLS 2006). The remaining Central Sand Hills counties had considerably higher unemployment rates, ranging from 5.5% in Green Lake County to 6.0% in Marquette County. Unemployment rates became much higher throughout the state after 2008 but have become lower again.

Poverty

Poverty Rates. The U.S. Census Bureau estimated that the Central Sand Hills counties' combined 2005 poverty rate for all people (8.7%) was less than the rate for the state as a whole (10.2%) (USCB 2009). Columbia County has the sixth-lowest poverty rate statewide (6.2%), while the remaining Central Sand Hills counties had poverty rates ranging from 7.4% in Green Lake County to 11.3% in Portage County.

Child Poverty Rates. Child poverty appears to be more of a concern for some Central Sand Hills counties than others. Compared to the statewide average (14%), only Waushara (16.4%) and Marquette (16.1%) counties have relatively high 2005 estimates of poverty rates for people under age 18 (USCB 2009). The remaining Central Sand Hills counties had relatively low childhood poverty rates, ranging from 11.9% in Green Lake County to 7.5% in Columbia County. Notably, Portage County had the Central Sand Hills counties' highest overall poverty rate but the second-lowest childhood poverty rate (10.6%).

Residential Property Values

Overall, Central Sand Hills counties' residential property values ($124,482 per housing unit) are lower than the statewide average ($134,021 per housing unit; Table 9.9). Central Sand Hills counties' residential property values are highly variable among the five counties. Green Lake County ($171,501) had the highest valued residential property among Central Sand Hills counties, reflecting its relative prevalence of vacation and second homes. Columbia County's ($137,565) residential property was also more highly valued than statewide averages. The remaining Central Sand Hills counties had lower average residential property values, ranging from $101,571 in Portage County to $121,510 in Waushara County.

Important Economic sectors

Central Sand Hills counties together provided 97,938 jobs in 2007, or about 2.8% of the total employment in Wisconsin (Table 9.10; MIG 2009). Portage County (43,240 jobs in 2007) and Columbia County (29,695 jobs) are the major contributors of employment in the Central Sand Hills counties. The remaining counties provide relatively few jobs, with 10,066 jobs in Green Lake County, 9,000 jobs in Waushara County, and 5,937 jobs in Marquette County in 2007.

Table 9.8. *Economic indicators for the Central Sand Hills counties and Wisconsin.*

	Per capita income[a]	Average earnings per job[a]	Unemployment rate[b]	Poverty rate[c]
Wisconsin	**$34,405**	**$36,142**	**4.7%**	**10.2%**
Columbia	$34,796	$30,339	4.7%	6.2%
Green Lake	$31,761	$28,913	5.5%	7.4%
Marquette	$25,297	$25,825	6.0%	9.8%
Portage	$30,702	$31,575	4.5%	11.3%
Waushara	$24,639	$25,636	5.6%	10.3%
Central Sand Hills counties	**$30,777**	**$30,121**	**4.9%**	**8.7%**

[a]U.S. Bureau of Economic Analysis, 2006 figures.
[b]U.S. Bureau of Labor Statistics, Local Area Unemployment Statistics, 2006 figures.
[c]U.S. Bureau of the Census, Small Area Income and Poverty Estimates, 2005 figures.

Table 9.9. *Property values for the Central Sand Hills counties and Wisconsin, assessed in 2006 and collected in 2007.*

	Residential property value	Housing units	Residential property value per housing unit
Wisconsin	**$340,217,559,700**	**2,538,538**	**$134,021**
Columbia	$3,447,644,900	25,062	$137,565
Green Lake	$1,769,719,800	10,319	$171,501
Marquette	$1,068,862,600	9,446	$113,155
Portage	$2,934,090,500	28,887	$101,571
Waushara	$1,807,943,400	14,879	$121,510
Central Sand Hills counties	**$11,028,261,200**	**88,593**	**$124,482**

Sources: Wisconsin Department of Revenue 2006–2007 property tax master file (except housing units); housing units: U. S. Census Bureau estimates for July 1, 2006.

Although the local economy among the Central Sand Hills counties is diverse, Government (13.2% of employment in the Central Sand Hills counties), Tourism-related (12.6%), and Manufacturing (non-wood) (12.0%) are the largest sectors in terms of employment (Table 9.10). Economic sectors of secondary importance in the Central Sand Hills counties include Health Care and Social Services (9.4% of the Central Sand Hills counties' employment), Retail Trade (9.1%), Other Services (7.0%), Agriculture, Fishing and Hunting (6.6%), Finance and Insurance (6.2%), and Construction (5.8%). Finance and Insurance, though ranked seventh in terms of employment, provides many high-paying jobs in the Central Sand Hills counties and accounts for over 10% of economic output, second only to the Manufacturing (non-wood) sector. Forest Products and Processing comprises only 2.4% of employment in the Central Sand Hills counties but is the third-leading economic sector in terms of industry output ($0.9 billion in value in 2007) in the Central Sand Hills counties (MIG 2009). For definitions of economic sectors, see the U.S. Census Bureau's North American Industry Classification System web page (USCB 2013).

The importance of economic sectors within the Central Sand Hills counties when compared to the rest of the state was evaluated using an economic base analysis to yield a standard metric called a location quotient (Quintero 2007). Economic base analysis compares the percentage of all jobs in an ecological landscape county approximation for a given economic sector to the percentage of all jobs in the state for the same economic sector. For example, if 10% of the jobs within an ecological landscape county approximation are in the manufacturing sector and 10% of all jobs in the state are in the manufacturing sector, then the quotient would be 1.0, indicating that this ecological landscape county approximation contributes jobs to the manufacturing sector at the same rate as the statewide average. If the quotient is greater than 1.0, the ecological landscape county approximation is contributing more jobs to the sector than the state average. If the quotient is less than 1.0, the ecological landscape county approximation is contributing fewer jobs to the sector than the state average.

When compared with the rest of the state, the Central Sand Hills counties had ten economic sectors with location quotients higher than 1.0, indicating their relative importance within the five counties (Figure 9.14). Among economic sectors, the location quotient for Agriculture, Fishing, and Hunting is highest in this ecological landscape county approximation, providing more than twice the proportion of total jobs in Central Sand Hills counties as statewide. Among all ecological landscapes county approximations in the state, the highest location quotient for the Finance and Insurance sector occurs in the Central Sand Hills counties. Other economic sectors providing a percentage of jobs in the Central Sand Hills counties higher than the state average, listed in order of their relative proportional importance, are Mining;

Table 9.10. *Total and percentage of jobs in 2007 in each economic sector within the Central Sand Hills (CSH) counties. The economic sectors providing the highest percentage of jobs in the Central Sand Hills counties are highlighted in blue.*

Industry sector	WI employment	% of WI total	CSH counties employment	% of CSH counties total
Agriculture, Fishing & Hunting	110,408	3.1%	6,503	6.6%
Forest Products & Processing	88,089	2.5%	2,385	2.4%
Mining	3,780	0.1%	171	0.2%
Utilities	11,182	0.3%	334	0.3%
Construction	200,794	5.6%	5,637	5.8%
Manufacturing (non-wood)	417,139	11.7%	11,727	12.0%
Wholesale Trade	131,751	3.7%	2,274	2.3%
Retail Trade	320,954	9.0%	8,880	9.1%
Tourism-related	399,054	11.2%	12,356	12.6%
Transportation & Warehousing	108,919	3.1%	3,962	4.0%
Information	57,081	1.6%	763	0.8%
Finance & Insurance	168,412	4.7%	6,056	6.2%
Real Estate, Rental & Leasing	106,215	3.0%	2,145	2.2%
Professional, Science & Tech Services	166,353	4.7%	2,441	2.5%
Management	43,009	1.2%	312	0.3%
Administrative and Support Services	166,405	4.7%	1,934	2.0%
Private Education	57,373	1.6%	1,071	1.1%
Health Care & Social Services	379,538	10.7%	9,204	9.4%
Other Services	187,939	5.3%	6,820	7.0%
Government	430,767	12.1%	12,965	13.2%
Totals	**3,555,161**		**97,938**	**2.8%**

Source: IMPLAN, © MIG, Inc. 2009 (MIG 2009).

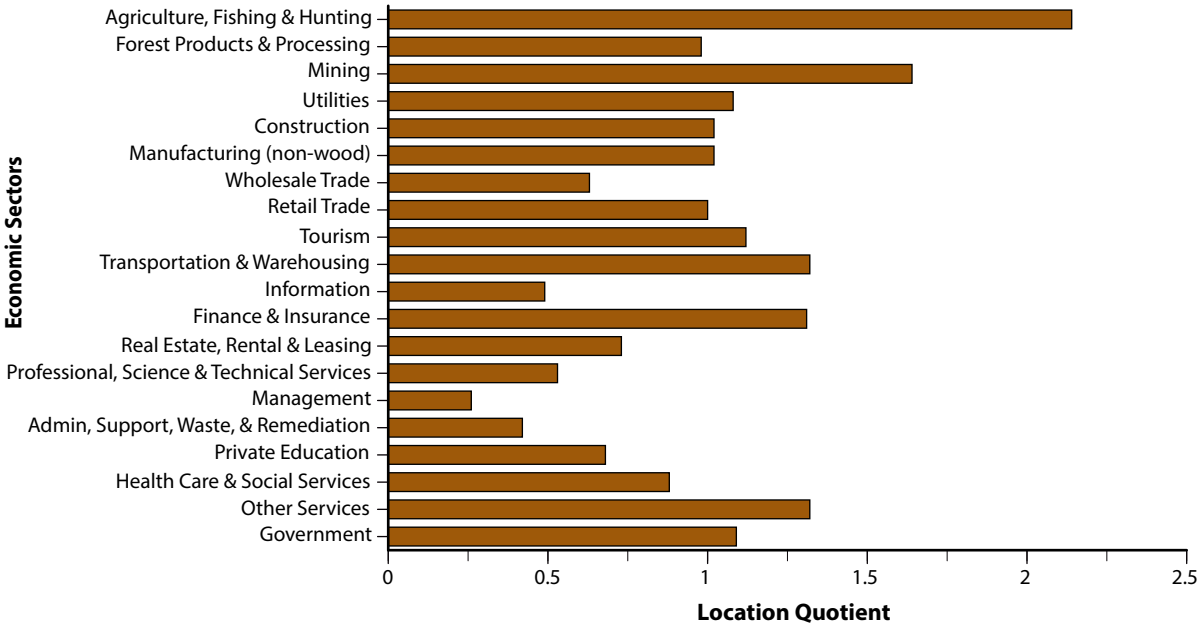


Figure 9.14. *Importance of economic sectors within the Central Sand Hills counties compared to the rest of the state. If the location quotient is greater than 1.0, the Central Sand Hills counties are contributing more jobs to that economic sector than the state average. If the location quotient is less than 1.0, the Central Sand Hills counties are contributing fewer jobs to that economic sector than the state average.*

Other Services; Transportation and Warehousing; Finance and Insurance; Tourism-related; Government; Utilities; Manufacturing (non-wood); and Construction (see Appendix 9.I at the end of this chapter).The Other Services sector consists primarily of equipment and machinery repairing, promoting or administering religious activities, grant making, advocacy, and providing dry-cleaning and laundry services, personal care services, death care services, pet care services, photo finishing services, and temporary parking services. The Tourism-related sector includes relevant subsectors within Retail Trade, Passenger Transportation, and Arts, Entertainment, and Recreation. The Tourism-related sector also includes all Accommodation and Food Services. The "Tourism-related sector" is not a separate economic sector as with other industrial classifications and is not easy to separate and identify. Businesses that service tourists also service local demands; however, they are the sectors most sensitive to tourism (Marcouiller and Xia 2008). The Forest Products and Processing sector includes subsectors in logging, pulp and paper manufacturing, primary wood manufacturing (e.g., sawmills), and secondary wood manufacturing (e.g., furniture manufacturing).

Urban Influence

U.S. Department of Agriculture's Economic Research Service (USDA ERS) divides counties into 12 groups on a continuum of urban influence: 1 represents large metropolitan areas, 2 represents smaller metropolitan areas, and the remaining classes from 3 to 12 represent nonmetropolitan counties increasingly less populated and isolated from urban influence (USDA ERS 2012b). The concept of urban influence assumes population size, urbanization, and access to larger adjacent economies are crucial elements in evaluating potential of local economies. Columbia County, located directly north of Dane County and the state capital of Madison, is the only urban Central Sand Hills county classified as a class 2 smaller metropolitan area. Portage County is a Class 5 county (micropolitan area adjacent to small metropolitan areas). Green Lake and Waushara counties are classified as class 6 counties, while Marquette County has the least urban influence among Central Sand Hills counties (class 7).

Economic Types

Based on the assumption that knowledge and understanding of different types of rural economies and their distinctive economic and sociodemographic profiles can aid rural policymaking, the USDA ERS classifies counties in one of six mutually exclusive categories: farming-dependent counties, mining-dependent counties, manufacturing-dependent counties, government-dependent counties, service-dependent counties, and nonspecialized counties (USDA ERS 2012a). Central Sand Hills counties were split among manufacturing-dependent (Columbia and Marquette) and nonspecialized (Green Lake, Portage, and Waushara) counties, according to the USDA ERS economic specialization definitions.

Policy Types

The USDA ERS also classifies counties according to "policy types" deemed especially relevant to rural development policy. Green Lake County is cited only as a nonmetro recreation county. Nonmetro recreation counties are rural counties classified using a combination of factors, including share of employment or share of earnings in recreation-related industries in

1999, share of seasonal or occasional use housing units in 2000, and per capita receipts from motels and hotels in 1997, indicating economic dependence especially upon an influx of tourism and recreational dollars (USDA ERS 2012a). Retirement destination counties (those in which the number of residents 60 and older grew by 15% or more between 1990 and 2000 due to in-migration) are shaped by an influx of an aging population and have particular needs for health care and services specific to that population. Marquette and Waushara counties were classified as both nonmetro recreation and retirement destination counties.

Integrated Opportunities for Management

Use of natural resources for human needs within the constraints of sustainable ecosystems is an integral part of ecosystem management. Integrating ecological management with socioeconomic programs or activities can result in efficiencies in land use, tax revenues, and private capital. This type of integration can also help generate broader and deeper support for sustainable ecosystem management. However, any human modification or use of natural communities has trade-offs that benefit some species and harm others. Even relatively benign activities such as ecotourism will have impacts on the ecology of an area. Trade-offs caused by management actions need to be carefully weighed during the planning process to ensure that some species are not being irreparably harmed. Maintaining healthy, sustainable ecosystems provides many benefits to people and our economy. The development of ecologically sound management plans should save money and sustain natural resources in the long run.

The principles of integrating natural resources and socioeconomic activities are similar across the state. A discussion of "Integrated Ecological and Socioeconomic Opportunities" can be found in Chapter 6, "Wisconsin's Ecological Features and Opportunities for Management." That section offers suggestions on how and when ecological and socioeconomic needs might be integrated and gives examples of the types of activities that might work together when planning the management of natural resources within a given area.

Appendices

Appendix 9.A. *Watershed water quality summary for the Central Sand Hills Ecological Landscape.*

Watershed number	Watershed name	Area (acres)	Overall water quality and major stressors[a] (Range = Very Poor/Poor/Fair/Good/Very Good/Excellent)
CW01	Little Roche A Cri Creek[b]	125,567	Not yet summarized by WDNR Bureau of Watershed Management
CW06	Big Roche A Cri Creek	113,279	Very Good; agr NPS
CW07	Fourteenmile Creek	117,856	Not yet summarized by WDNR Bureau of Watershed Management
CW09	Sevenmile and Tenmile creeks	71,834	Not yet summarized by WDNR Bureau of Watershed Management
CW10	Fourmile and Fivemile creeks	136,033	Not yet summarized by WDNR Bureau of Watershed Management
CW12	Plover and Little Plover rivers	129,402	Good to Very Good; hi-cap wells, low flows, agr NPS
LW17	Black Earth Creek	67,325	Very Good; Drained wetlands; urbanization; agr erosion
LW18	Roxbury Creek	45,513	Good to Fair; NPS, ditching; stream grazing; loosetrife
LW19	Lake Wisconsin	137,576	Excellent to Fair; NPS; stream channelization; atrazine; excess nutrients; PCBs
LW20	Duck Creek and Rocky Run	90,173	Very Good to Poor; manure; diversion; ditching, small dams
LW21	Lower Baraboo River	96,344	Excellent to Fair; agr wetland drainage; NPS; atrazine
UF05	Fox River/Rush Lake	76,644	Fair; agr NPS; carp; phosphorous goes to Lake Winnebago
UF06	Fox River/Berlin	133,596	Fair to Good; phosphorous goes to Lake Winnebago
UF07	Big Green Lake	68,677	Fair to Very Good; Some agr NPS sources remain; stream bank erosion; gulleying continues; Ripon PS; carp
UF08	White River	95,880	Good; some agr sedimentation and excess nutrients
UF09	Mecan River	94,918	Good to Excellent; excess nutrients in Pleasant Lake
UF10	Buffalo and Puckaway lakes	144,072	Fair to Good; PCBs/pesticides in fish; shallow lakes eutrophic
UF11	Lower Grand River	70,012	Good to Fair; agr NPS; sedimentation; carp
UF12	Upper Grand River	39,652	Good to Poor; Soil loss; canning waste nutrient potential
UF13	Montello River	96,079	Good to Very Good, except Fair in Montello Lake w/high nutrients
UF14	Neenah Creek	110,941	Excellent to fair; dam thermal impacts
UF15	Swan Lake	51,593	Animal waste; streambank trampling; excessive P to Fox River; lake algal blooms
UR03[b]	Beaver Dam River	186,760	Fair to Poor; pesticides; sediments and nutrients; low D.O.
UR06	Upper Crawfish River	103,154	Fair to Poor; excess NPS agr nutrients; low flows; sediment
WR02	Pine and Willow rivers	193,329	Good to Fair; animal waste; erosion,; mill ponds
WR03	Walla Walla and Alder creeks	71,739	Good to Fair; animal waste; soil erosion; ditching
WR05	Waupaca River	186,096	Very Good; animal waste on sandy soil; hi-cap wells

Source: Wisconsin DNR Bureau of Watershed Management data.

[a]Based on Wisconsin DNR watershed water quality reports.

[b]Only a small fraction of this watershed lies within the Central Sand Hills, so overall impacts of land uses within this ecological landscape are unlikely to impact water quality within the watershed to any appreciable degree.

Abbreviations:
Agr = Agricultural.
D.O. = Dissolved oxygen.
Hi-cap wells = High capacity wells.
NPS = Nonpoint source pollutants, such as farm or parking lot runoff, or septic system leakage.
P = Phosphorus in excessive amounts, reducing oxygen concentrations in a waterbody.
PCBs = Polychlorinated biphenyl industrial pollutants in sediment and aquatic life.
PS = Point source pollutants, such as treated municipal and industrial wastewater.

Appendix 9.B. *Forest habitat types in the Central Sand Hills Ecological Landscape.*

The forest habitat type classification system (FHTCS) is a site classification system based on the floristic composition of plant communities. The system depends on the identification of potential climax associations, repeatable patterns in the composition of the understory vegetation, and differential understory species. It groups land units with similar capacity to produce vegetation. The floristic composition of the plant community is used as an integrated indicator of those environmental factors that affect species reproduction, growth, competition, and community development. This classification system enables the recognition and classification of ecologically similar landscape units (site types) and forest plant communities (vegetation associations).

A forest habitat type is an aggregation of sites (units of land) capable of producing similar late-successional (potential climax) forest plant communities. Each recognizable habitat type represents a relatively narrow segment of environmental variation that is characterized by a certain limited potential for vegetation development. Although at any given time, a habitat type can support a variety of disturbance-induced (seral) plant communities, the ultimate product of succession is presumed to be a similar climax community. Field identification of a habitat type provides a convenient label (habitat type name) for a given site, and places that site in the context of a larger group of sites that share similar ecological traits. Forest habitat type groups more broadly combine individual habitat types that have similar ecological potentials.

Individual forest cover types classify current overstory vegetation, but these associations usually encompass a wide range of environmental conditions. In contrast, individual habitat types group ecologically similar sites in terms of vegetation potentials. Management interpretations can be refined and made significantly more accurate by evaluating a stand in terms of the current cover type (current dominant vegetation) plus the habitat type (potential vegetation).

Habitat types	Description of forest habitat types found in the Central Sand Hills Ecological Landscape.
ArDe	*Acer rubrum/Desmodium* Red maple/Pointed-leaf tick trefoil
ATiFrCi	*Acer saccharum-Tilia americana-Fraxinus americana/Circaea* Sugar maple-Basswood-White ash/Enchanter's nightshade
ATiFrVb(Cr)	*Acer saccharum-Tilia americana-Fraxinus americana/Viburnum, Cornus racemosa* variant Sugar maple-Basswood-White ash/Viburnum, Gray dogwood variant
ATiFrVb	*Acer saccharum-Tilia americana-Fraxinus americana/Viburnum* Sugar maple-Basswood-White ash/Viburnum
ATiFrCa(O)	*Acer saccharum-Tilia americana-Fraxinus americana/Caulophyllum, Osmorhiza* variant Sugar maple-Basswood-White ash/Blue cohosh, Sweet cicely phase
PEu	*Pinus strobus/Euphorbia corollata* White pine/Flowering spurge
PVG	*Pinus strobus/Vaccinium-Gaultheria* White pine/Blueberry-Wintergreen

Source: Kotar and Burger (1996).

Appendix 9.C. *The Natural Heritage Inventory (NHI) table of rare species and natural community occurrences (plus a few miscellaneous features tracked by the NHI program) for the Central Sand Hills (CSH) Ecological Landscape in November 2009. See the Wisconsin Natural Heritage Working List online for the current status (http://dnr.wi.gov, keyword "NHI").*

Scientific name (common name)	Lastobs date	EOs[a] in CSH	EOs in WI	Percent in CSH	State rank	Global rank	State status	Federal status
MAMMALS[b]								
Canis lupus (gray wolf)	2008	1	204	0%	S2	G4	SC/FL	LE
Microtus ochrogaster (prairie vole)	1996	3	19	16%	S1S2	G5	SC/N	
Sorex arcticus (arctic shrew)	1998	2	31	6%	S3S4	G5	SC/N	
Sorex hoyi (pygmy shrew)	1997	2	39	5%	S3S4	G5	SC/N	
BIRDS[c]								
Accipiter gentilis (Northern Goshawk)	2005	2	141	1%	S2B,S2N	G5	SC/M	
Ammodramus henslowii (Henslow's Sparrow)	2009	7	82	9%	S3B	G4	THR	
Asio otus (Long-eared Owl)	2005	2	8	25%	S2B	G5	SC/M	
Bartramia longicauda (Upland Sandpiper)	2002	1	54	2%	S2B	G5	SC/M	
Botaurus lentiginosus (American Bittern)	2009	2	41	5%	S3B	G4	SC/M	
Buteo lineatus (Red-shouldered Hawk)	2006	15	301	5%	S3S4B,S1N	G5	THR	
Chlidonias niger (Black Tern)	2009	4	60	7%	S2B	G4	SC/M	
Coccyzus americanus (Yellow-billed Cuckoo)	2009	2	39	5%	S3B	G5	SC/M	
Colinus virginianus (Northern Bobwhite)	2009	1	2	50%	S3B	G5	SC/M	
Coturnicops noveboracensis (Yellow Rail)	2005	1	22	5%	S1B	G4	THR	
Dendroica cerulea (Cerulean Warbler)[d]	2009	2	92	2%	S2S3B	G4	THR	
Empidonax virescens (Acadian Flycatcher)	2009	1	47	2%	S3B	G5	THR	
Gallinula chloropus (Common Moorhen)	2009	1	10	10%	S2B	G5	SC/M	
Haliaeetus leucocephalus (Bald Eagle)	2008	16	1286	1%	S4B,S2N	G5	SC/P	
Icteria virens (Yellow-breasted Chat)	2002	1	2	50%	S2B	G5	SC/M	
Ixobrychus exilis (Least Bittern)	2009	2	23	9%	S3B	G5	SC/M	
Lanius ludovicianus (Loggerhead Shrike)	2001	2	31	6%	S1B	G4	END	
Nyctanassa violacea (Yellow-crowned Night-heron)	1987	1	7	14%	S1B	G5	THR	
Nycticorax nycticorax (Black-crowned Night-heron)	1988	4	36	11%	S2B	G5	SC/M	
Pandion haliaetus (Osprey)	2008	15	733	2%	S4B	G5	SC/M	
Podiceps grisegena (Red-necked Grebe)	1997	2	13	15%	S1B	G5	END	
Rallus elegans (King Rail)	2006	2	6	33%	S1B	G4	SC/M	
Spiza americana (Dickcissel)	2005	5	46	11%	S3B	G5	SC/M	
Sterna forsteri (Forster's Tern)	1996	3	31	10%	S1B	G5	END	
Sturnella neglecta (Western Meadowlark)	2002	1	39	3%	S2B	G5	SC/M	
Tympanuchus cupido (Greater Prairie-chicken)	1979	1	60	2%	S1B,S2N	G4	THR	
Tyto alba (Barn Owl)	1981	2	29	7%	S1B,S1N	G5	END	
Vireo bellii (Bell's Vireo)	2009	6	43	14%	S2B	G5	THR	
HERPTILES								
Acris crepitans (northern cricket frog)	1988	3	102	3%	S1	G5	END	
Apalone mutica (smooth softshell)	1979	1	5	20%	S3	G5	SC/H	
Coluber constrictor (North American racer)	1999	1	14	7%	S2	G5	SC/P	
Crotalus horridus (timber rattlesnake)	2008	3	61	5%	S2S3	G4	SC/P	
Emydoidea blandingii (Blanding's turtle)	2009	36	316	11%	S3	G4	THR	
Glyptemys insculpta (wood turtle)	1987	4	262	2%	S2	G4	THR	
Graptemys pseudogeographica (false map turtle)	1976	1	1	100%	S4	G5	SC/H	
Hemidactylium scutatum (four-toed salamander)	1981	1	63	2%	S3	G5	SC/H	
Heterodon platirhinos (eastern hog-nosed snake)	2009	4	6	67%	S3?	G5	SC/H	
Lithobates catesbeianus (American bullfrog)	1997	2	70	3%	S3	G5	SC/H	

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Appendix 9.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in CSH	EOs in WI	Percent in CSH	State rank	Global rank	State status	Federal status
Lithobates palustris (pickerel frog)	2009	1	2	50%	S3S4	G5	SC/H	
Ophisaurus attenuatus (slender glass lizard)	2009	31	67	46%	S1	G5	END	
Pituophis catenifer (gophersnake)	1999	1	29	3%	S2S3	G5	SC/P	
Sistrurus catenatus catenatus (eastern massasauga)	1977	2	13	15%	S1	G3G4T3T4Q	END	C
Terrapene ornata (ornate box turtle)	2009	8	29	28%	S1	G5	END	
Thamnophis proximus (western ribbonsnake)	1975	1	2	50%	S1	G5	END	
FISHES								
Acipenser fulvescens (lake sturgeon)	1991	3	99	3%	S3	G3G4	SC/H	
Aphredoderus sayanus (pirate perch)	1985	1	39	3%	S3	G5	SC/N	
Cycleptus elongatus (blue sucker)	2008	1	8	13%	S2	G3G4	THR	
Erimyzon sucetta (lake chubsucker)	1991	4	85	5%	S3	G5	SC/N	
Etheostoma clarum (western sand darter)	1994	1	11	9%	S3	G3	SC/N	
Etheostoma microperca (least darter)	1979	3	83	4%	S3	G5	SC/N	
Fundulus diaphanus (banded killifish)	1998	8	105	8%	S3	G5	SC/N	
Hiodon alosoides (goldeye)	1990	1	8	13%	S2	G5	END	
Ictiobus niger (black buffalo)	1980	2	11	18%	S2	G5	THR	
Lepomis megalotis (longear sunfish)	2003	1	25	4%	S2	G5	THR	
Lythrurus umbratilis (redfin shiner)	1979	2	37	5%	S2	G5	THR	
Macrhybopsis aestivalis (shoal chub)	1994	1	10	10%	S2	G5	THR	
Macrhybopsis storeriana (silver chub)	1993	1	13	8%	S3	G5	SC/N	
Moxostoma valenciennesi (greater redhorse)	1978	2	56	4%	S3	G4	THR	
Notropis anogenus (pugnose shiner)	1979	2	49	4%	S2	G3	THR	
Notropis texanus (weed shiner)	1979	2	45	4%	S3	G5	SC/N	
Opsopoeodus emiliae (pugnose minnow)	1984	2	31	6%	S3	G5	SC/N	
MUSSELS/CLAMS								
Alasmidonta marginata (elktoe)	1997	1	44	2%	S4	G4	SC/P	
Arcidens confragosus (rock pocketbook)	1997	1	5	20%	S1S2	G4	THR	
Plethobasus cyphyus (bullhead/sheepnose)[e]	1993	1	5	20%	S1	G3	END	C
Pleurobema sintoxia (round pigtoe)	1997	3	50	6%	S3	G4G5	SC/P	
Quadrula metanevra (monkeyface)	1993	1	11	9%	S2	G4	THR	
Simpsonaias ambigua (salamander mussel)	1993	1	51	2%	S2S3	G3	THR	
Tritogonia verrucosa (buckhorn)	1994	3	12	25%	S2	G4G5	THR	
MISCELLANEOUS INVERTEBRATES								
Catinella exile (Pleistocene catinella)	1997	1	4	25%	S2	G2	SC/N	
Strobilops affinis (eightfold pinecone)	1997	1	7	14%	S3	G4G5	SC/N	
Vertigo elatior (tapered vertigo)	1997	1	12	8%	S3	G5	SC/N	
Vertigo morsei (six-whorl vertigo)	1997	1	3	33%	S1	G3	SC/N	
BUTTERFLIES/MOTHS								
Calephelis muticum (swamp metalmark)	2001	1	12	8%	S1	G3	END	
Callophrys gryneus (juniper hairstreak)	1991	1	8	13%	S3	G5	SC/N	
Callophrys henrici (Henry's elfin)	2006	2	19	11%	S1S2	G5	SC/N	
Catocala abbreviatella (abbreviated underwing moth)	1997	2	8	25%	S3	G4	SC/N	
Catocala whitneyi (Whitney's underwing moth)	1997	2	10	20%	S3	G3G4	SC/N	
Chlosyne gorgone (gorgone checker spot)	2002	4	40	10%	S3	G5	SC/N	
Erynnis persius (Persius dusky wing)	1998	1	26	4%	S2	G5	SC/N	
Grammia phyllira (Phyllira tiger moth)	1999	1	14	7%	S2	G4	SC/N	
Hemileuca sp. 3 (midwestern fen buckmoth)	1997	1	10	10%	S3	G5T3T4	SC/N	

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Appendix 9.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in CSH	EOs in WI	Percent in CSH	State rank	Global rank	State status	Federal status
Hesperia leonardus (Leonard's skipper)	2000	2	29	7%	S3	G4	SC/N	
Hesperia ottoe (Ottoe skipper)	1992	2	16	13%	S2	G3G4	SC/N	
Lycaeides melissa samuelis (Karner blue)	2006	52	316	16%	S3	G5T2	SC/FL	LE
Lycaena dione (gray copper)	1991	1	14	7%	S2	G5	SC/N	
Macrochilo bivittata (an owlet moth)	1997	1	8	13%	S3	G3G4	SC/N	
Papaipema silphii (Silphium borer moth)	1995	3	15	20%	S2	G3G4	END	
Poanes massasoit (mulberry wing)	2009	7	56	13%	S3	G4	SC/N	
Poanes viator (broad-winged skipper)	1991	1	36	3%	S3	G5	SC/N	
Satyrium caryaevorum (hickory hairstreak)	1991	1	3	33%	S2	G4	SC/N	
Speyeria idalia (regal fritillary)	2006	1	24	4%	S1	G3	END	
DRAGONFLIES/DAMSELFLIES								
Enallagma anna (river bluet)	1986	1	4	25%	S2	G5	SC/N	
Ischnura hastata (citrine forktail)	1989	1	2	50%	S2	G5	SC/N	
Nasiaeschna pentacantha (cyrano darner)	1988	1	14	7%	S3	G5	SC/N	
Neurocordulia molesta (smoky shadowfly)	1994	1	9	11%	S2S3	G4	SC/N	
Rhionaeschna mutata (spatterdock darner)	1989	3	3	100%	S1	G4	THR	
Stylurus plagiatus (russet-tipped clubtail)	1995	2	8	25%	S2	G5	SC/N	
Sympetrum danae (black meadowhawk)	1990	1	6	17%	S3	G5	SC/N	
BEETLES								
Cicindela macra (a tiger beetle)	1979	1	3	33%	S1S2	G5	SC/N	
Cicindela patruela huberi (a tiger beetle)	2000	9	84	11%	S3	G3T3	SC/N	
Haliplus pantherinus (a crawling water beetle)	2000	1	13	8%	S2S3	GNR	SC/N	
Hydrocanthus iricolor (a burrowing water beetle)	1984	1	1	100%	S1	GNR	SC/N	
Hygrotus sylvanus (Sylvan hygrotus diving beetle)	1990	1	3	33%	S1	GU	SC/N	
Laccobius agilis (a water scavenger beetle)	2000	1	4	25%	S2S3	GNR	SC/N	
Lioporeus triangularis (a predaceous diving beetle)	1985	1	4	25%	S1S2	GNR	SC/N	
MISCELLANEOUS INSECTS/SPIDERS								
Aflexia rubranura (red-tailed prairie leafhopper)	1996	1	25	4%	S2	G2	END	
Paracloeodes minutus (a small minnow mayfly)	1992	2	4	50%	S1?	G5	SC/N	
Polyamia dilata (prairie leafhopper)	1998	3	20	15%	S2	GNR	THR	
Prairiana angustens (a leafhopper)	1996	1	1	100%	S1S3	GNR	SC/N	
Prairiana cinerea (a leafhopper)	1986	1	6	17%	S2S3	GNR	SC/N	
Spinadis simplex (Wallace's deepwater mayfly)	1974	1	4	25%	S1	G2G4	END	
PLANTS								
Agastache nepetoides (yellow giant hyssop)	2008	1	30	3%	S3	G5	THR	
Asclepias lanuginosa (woolly milkweed)	2009	4	16	25%	S1	G4?	THR	
Asclepias ovalifolia (dwarf milkweed)	2001	1	60	2%	S3	G5?	THR	
Asclepias purpurascens (purple milkweed)	1984	2	39	5%	S3	G5?	END	
Aster dumosus var. *strictior* (bushy aster)	1990	1	1	100%	S1	G5T4	SC	
Baptisia tinctoria (yellow wild-indigo)	1973	1	2	50%	S1	G5	SC	
Cacalia muehlenbergii (great Indian-plantain)	1973	1	25	4%	S2S3	G4	SC	
Cacalia suaveolens (sweet-scented Indian-plantain)	2009	4	28	14%	S3	G4	SC	
Calamagrostis stricta (slim-stem small-reedgrass)	2001	3	34	9%	S3	G5	SC	
Cardamine pratensis (cuckooflower)	1971	1	42	2%	S3	G5	SC	
Carex crawei (Crawe sedge)	2001	1	24	4%	S3	G5	SC	
Carex livida var. *radicaulis* (livid sedge)	2005	2	21	10%	S2	G5T5	SC	
Carex lupuliformis (false hop sedge)	1990	2	11	18%	S1	G4	END	

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Appendix 9.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in CSH	EOs in WI	Percent in CSH	State rank	Global rank	State status	Federal status
Carex sychnocephala (many-headed sedge)	2001	7	15	47%	S2	G4	SC	
Catabrosa aquatica (brook grass)	2001	1	1	100%	S1	G5	END	
Cirsium flodmanii (Flodman thistle)	2009	1	2	50%	S1	G5	SC	
Cirsium hillii (Hill's thistle)	2009	2	58	3%	S3	G3	THR	
Cypripedium candidum (small white lady's-slipper)	2003	6	47	13%	S3	G4	THR	
Cypripedium parviflorum var. *makasin* (northern yellow lady's-slipper)	1986	1	78	1%	S3	G5T4Q	SC	
Cypripedium reginae (showy lady's-slipper)	1988	5	99	5%	S3	G4	SC	
Deschampsia cespitosa (tufted hairgrass)	2006	4	17	24%	S2	G5	SC	
Diarrhena obovata (beak grass)	2001	1	11	9%	S2	G4G5	END	
Diodia teres var. *teres* (buttonweed)	2009	1	4	25%	S1	G5T5	SC	
Drosera linearis (slenderleaf sundew)	2005	1	5	20%	S1	G4	THR	
Eleocharis compressa (flat-stemmed spike-rush)	2000	2	9	22%	S2	G4	SC	
Eleocharis engelmannii (Engelmann spike-rush)	2001	1	4	25%	S1	G4G5Q	SC	
Eleocharis quinqueflora (few-flower spikerush)	2000	1	18	6%	S2	G5	SC	
Eleocharis robbinsii (Robbins' spikerush)	1990	3	28	11%	S3	G4G5	SC	
Epilobium strictum (downy willow-herb)	1992	2	22	9%	S2S3	G5?	SC	
Equisetum variegatum (variegated horsetail)	2000	1	47	2%	S3	G5	SC	
Eriophorum alpinum (alpine cotton-grass)	2005	1	25	4%	S2	G5	SC	
Fuirena pumila (dwarf umbrella-sedge)	1992	1	1	100%	S1	G4	END	
Gentiana alba (yellow gentian)	1990	1	80	1%	S3	G4	THR	
Gentianopsis procera (lesser fringed gentian)	2001	6	66	9%	S3	G5	SC	
Lespedeza leptostachya (prairie bush-clover)	1993	1	22	5%	S2	G3	END	LT
Microseris cuspidata (prairie false-dandelion)	2009	2	15	13%	S2	G5	SC	
Muhlenbergia richardsonis (soft-leaf muhly)	1994	1	2	50%	S1	G5	END	
Myosotis laxa (small forget-me-not)	1993	2	9	22%	S2	G5	SC	
Myriophyllum farwellii (Farwell's water-milfoil)	1973	1	60	2%	S3	G5	SC	
Opuntia fragilis (brittle prickly-pear)	2001	10	36	28%	S3	G4G5	THR	
Oxytropis campestris var. *chartacea* (Fassett's locoweed)	2008	6	8	75%	S1S2	G5T1T2	END	LT
Pellaea atropurpurea (purple-stem cliff-brake)	1993	4	16	25%	S2	G5	SC	
Platanthera flava var. *herbiola* (pale green orchid)	2006	6	20	30%	S2	G4T4Q	THR	
Poa paludigena (bog bluegrass)	1987	1	41	2%	S3	G3	THR	
Polygala cruciata (crossleaf milkwort)	1990	1	83	1%	S3	G5	SC	
Polytaenia nuttallii (prairie parsley)	1992	2	26	8%	S3	G5	THR	
Psilocarya scirpoides (long-beaked baldrush)	2000	6	6	100%	S2	G4	THR	
Rhexia virginica (Virginia meadow-beauty)	1995	4	22	18%	S3	G5	SC	
Rhus aromatica (fragrant sumac)	1993	2	5	40%	S1	G5	SC	
Scirpus cespitosus (tufted bulrush)	2007	2	20	10%	S2	G5	THR	
Scirpus heterochaetus (slender bulrush)	1977	1	2	50%	S1	G5	SC	
Scleria triglomerata (whip nutrush)	2005	2	17	12%	S2S3	G5	SC	
Scleria verticillata (low nutrush)	1984	2	10	20%	S2	G5	SC	
Silene virginica (fire pink)	2008	1	2	50%	S1	G5	END	
Solidago sciaphila (shadowy goldenrod)	1993	3	57	5%	S3	G3G4	SC	
Talinum rugospermum (prairie fame-flower)	2006	7	54	13%	S3	G3G4	SC	
Tofieldia glutinosa (sticky false-asphodel)	2001	3	23	13%	S2S3	G4G5	THR	
Triglochin maritima (common bog arrow-grass)	2005	2	59	3%	S3	G5	SC	
Triglochin palustris (slender bog arrow-grass)	2000	2	36	6%	S3	G5	SC	
Utricularia purpurea (purple bladderwort)	2002	3	55	5%	S3	G5	SC	
Utricularia resupinata (northeastern bladderwort)	1976	1	29	3%	S3	G4	SC	

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Appendix 9.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in CSH	EOs in WI	Percent in CSH	State rank	Global rank	State status	Federal status
COMMUNITIES								
Alder Thicket	2000	6	106	6%	S4	G4	NA	
Bedrock Glade	1990	2	20	10%	S3	G2	NA	
Calcareous Fen	2000	22	84	26%	S3	G3	NA	
Cedar Glade	1978	5	16	31%	S4	GNR	NA	
Coastal Plain Marsh	1978	4	6	67%	S1	G2?	NA	
Dry Cliff	1978	4	88	5%	S4	G4G5	NA	
Dry Prairie	1995	11	146	8%	S3	G3	NA	
Dry-mesic Prairie	1995	1	37	3%	S2	G3	NA	
Emergent Marsh	1994	30	272	11%	S4	G4	NA	
Floodplain Forest	2002	8	182	4%	S3	G3?	NA	
Hardwood Swamp	2006	2	53	4%	S3	G4	NA	
Inland Beach	2000	9	17	53%	S3	G4G5	NA	
Lake—Deep, Hard, Drainage	1977	2	30	7%	S3	GNR	NA	
Lake—Deep, Hard, Seepage	1983	4	22	18%	S2	GNR	NA	
Lake—Oxbow	1978	1	14	7%	SU	GNR	NA	
Lake—Shallow, Hard, Drainage	1979	3	35	9%	SU	GNR	NA	
Lake—Shallow, Hard, Seepage	1988	6	52	12%	SU	GNR	NA	
Lake—Shallow, Soft, Seepage	1979	5	87	6%	S4	GNR	NA	
Lake—Soft Bog	1978	1	52	2%	S4	GNR	NA	
Mesic Prairie	1987	3	44	7%	S1	G2	NA	
Moist Cliff	1979	5	176	3%	S4	GNR	NA	
Moist Sandy Meadow	1986	1	3	33%	SU	GNR	NA	
Northern Dry Forest	1981	5	63	8%	S3	G3?	NA	
Northern Dry-mesic Forest	2006	12	284	4%	S3	G4	NA	
Northern Sedge Meadow	1984	12	231	5%	S3	G4	NA	
Northern Wet Forest	1985	21	322	7%	S4	G4	NA	
Northern Wet-mesic Forest	1978	1	243	0%	S3S4	G3?	NA	
Oak Barrens	2001	8	38	21%	S2	G2?	NA	
Oak Opening	1995	3	25	12%	S1	G1	NA	
Oak Woodland	1999	2	10	20%	S1?	GNR	NA	
Open Bog	2002	4	173	2%	S4	G5	NA	
Pine Barrens	2000	2	56	4%	S2	G2	NA	
Sand Barrens	1979	3	29	10%	SU	GNR	NA	
Sand Prairie	1979	1	28	4%	S2	GNR	NA	
Shrub-carr	1983	15	143	10%	S4	G5	NA	
Southern Dry Forest	2000	16	97	16%	S3	G4	NA	
Southern Dry-mesic Forest	1985	14	293	5%	S3	G4	NA	
Southern Mesic Forest	2006	4	221	2%	S3	G3?	NA	
Southern Sedge Meadow	2006	27	182	15%	S3	G4?	NA	
Southern Tamarack Swamp (Rich)	1987	4	32	13%	S3	G3	NA	
Spring Pond	2006	6	69	9%	S3	GNR	NA	
Springs and Spring Runs, Hard	2006	14	71	20%	S4	GNR	NA	
Stream—Fast, Hard, Cold	1984	6	98	6%	S4	GNR	NA	
Stream—Fast, Soft, Warm	1978	1	5	20%	SU	GNR	NA	
Stream—Slow, Hard, Cold	1978	1	22	5%	SU	GNR	NA	
Stream—Slow, Soft, Warm	1978	1	14	7%	SU	GNR	NA	
Wet Prairie	2000	4	22	18%	SU	G3	NA	
Wet-mesic Prairie	1978	12	81	15%	S2	G2	NA	
OTHER ELEMENTS								
Migratory bird concentration site	1979	1	8	13%	SU	G3	SC	

Continued on next page

Appendix 9.C, *continued.*

[a]An element occurrence is an area of land and/or water in which a rare species or natural community is, or was, present. Element occurrences must meet strict criteria that is used by an international network of Heritage programs and coordinated by NatureServe.
[b]Northern long-eared bat (*Myotis septentrionalis*) was listed as Wisconsin Threatened on 6/01/2011 and as U.S. Threatened on 5/04/2015.
[c]The common names of birds are capitalized in accordance with the checklist of the American Ornithologists Union.
[d]The American Ornithologist's Union lists this bird name as Cerulean Warbler (*Setophaga cerulea*).
[e]Bullhead (sheepnose) mussel (*Plethobasus cyphyus*) was listed as U.S. Endangered on 4/12/2012.

STATUS AND RANKING DEFINITIONS

U.S. Status—Current federal protection status designated by the Office of Endangered Species, U.S. Fish and Wildlife Service, indicating the biological status of a species in Wisconsin:

LE = listed endangered.
LT = listed threatened.
PE = proposed as endangered.
NEP = nonessential experimental population.
C = candidate for future listing.
CH = critical habitat.

State Status—Protection category designated by the Wisconsin DNR:

END = Endangered. Endangered species means any species whose continued existence as a viable component of this state's wild animals or wild plants is determined by the Wisconsin DNR to be in jeopardy on the basis of scientific evidence.
THR = Threatened species means any species of wild animals or wild plants that appears likely, within the foreseeable future, on the basis of scientific evidence to become endangered.
SC = Special Concern. Special Concern species are those species about which some problem of abundance or distribution is suspected but not yet proven. The main purpose of this category is to focus attention on certain species before they become threatened or endangered.

Wisconsin DNR and federal regulations regarding Special Concern species range from full protection to no protection. The current categories and their respective level of protection are as follows:

SC/P = fully protected;
SC/N = no laws regulating use, possession, or harvesting;
SC/H = take regulated by establishment of open closed seasons;
SC/FL = federally protected as endangered or threatened but not so designated by Wisconsin DNR;
SC/M = fully protected by federal and state laws under the Migratory Bird Act.

Global Element Ranks:

G1 = Critically imperiled globally because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.
G2 = Imperiled globally because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.
G3 = Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a single state or physiographic region) or because of other factor(s) making it vulnerable to extinction throughout its range; typically 21-100 occurrences.
G4 = Uncommon but not rare (although it may be quite rare in parts of its range, especially at the periphery) and usually widespread. Typically > 100 occurrences.
G5 = Common, widespread, and abundant (although it may be quite rare in parts of its range, especially at the periphery). Not vulnerable in most of its range.
GH = Known only from historical occurrence throughout its range, with the expectation that it may be rediscovered.
GNR = Not ranked. Replaced G? rank and some GU ranks.
GU = Currently unrankable due to lack of data or substantially conflicting data on status or trends. Possibly in peril range-wide, but status is uncertain.
GX = Presumed to be extinct throughout its range (e.g., Passenger pigeon) with virtually no likelihood that it will be rediscovered.

Species with a questionable taxonomic assignment are given a "Q" after the global rank. Subspecies and varieties are given subranks composed of the letter "T" plus a number or letter. The definition of the second character of the subrank parallels that of the full global rank. (Examples: a rare subspecies of a rare species is ranked G1T1; a rare subspecies of a common species is ranked G5T1.)

State Element Ranks:

S1 = Critically imperiled in Wisconsin because of extreme rarity, typically 5 or fewer occurrences and/or very few (<1,000) remaining individuals or acres, or due to some factor(s) making it especially vulnerable to extirpation from the state.
S2 = Imperiled in Wisconsin because of rarity, typically 6–20 occurrences and/or few (1,000– 3,000) remaining individuals or acres, or due to some factor(s) making it very vulnerable to extirpation from the state.
S3 = Rare or uncommon in Wisconsin, typically 21–100 occurrences and/or 3,000–10,000 individuals.
S4 = Apparently secure in Wisconsin, usually with > 100 occurrences and > 10,000 individuals.
S5 = Demonstrably secure in Wisconsin and essentially ineradicable under present conditions.
SNA = Accidental, nonnative, reported but unconfirmed, or falsely reported.
SH = Of historical occurrence in Wisconsin, perhaps having not been verified in the past 20 years and suspected to be still extant. Naturally, an element would become SH without such a 20-year delay if the only known occurrence were destroyed or if it had been extensively and unsuccessfully looked for.

Status and ranking definitions continued on next page

Appendix 9.C, *continued.*

SNR = Not Ranked; a state rank has not yet been assessed.
SU = Currently unrankable. Possibly in peril in the state, but status is uncertain due to lack of information or substantially conflicting data on status or trends.
SX = Apparently extirpated from the state.

State ranking of long-distance migrant animals:
Ranking long distance aerial migrant animals presents special problems relating to the fact that their nonbreeding status (rank) may be quite different from their breeding status, if any, in Wisconsin. In other words, the conservation needs of these taxa may vary between seasons. In order to present a less ambiguous picture of a migrant's status, it is necessary to specify whether the rank refers to the breeding (B) or nonbreeding (N) status of the taxon in question. (e.g., S2B, S5N).

Appendix 9.D. *Number of species with special designations documented within the Central Sand Hills Ecological Landscape, 2009.*

Listing status[a]	Taxa					Total fauna	Total flora	Total listed
	Mammals	Birds	Herptiles	Fishes	Invertebrates			
U.S. Endangered	1	0	0	0	1	2	0	2
U.S. Threatened	0	0	0	0	0	0	2	2
U.S. Candidate	0	0	1	0	1	2	0	2
Wisconsin Endangered	0	4	5	1	6	16	9	25
Wisconsin Threatened	0	8	2	7	6	23	14	37
Wisconsin Special Concern	4	16	9	9	38	76	38	114
Natural Heritage Inventory total	**4**	**28**	**16**	**17**	**50**	**115**	**61**	**176**

Note: State-listed species always include federally listed species (although they may not have the same designation); therefore, federally listed species are not included in the total.

[a]The bullhead (sheepnose) mussel (*Plethobasus cyphyus*) was listed as U.S. Endangered in 2012, and northern long-eared bat (*Myotis septentrionalis*) was listed as Wisconsin Threatened in 2012 and as U.S. Threatened in 2015. These species are not included in the numbers above.

Appendix 9.E. *Species of Greatest Conservation Need (SGCN) found in the Central Sand Hills Ecological Landscape.*

These SGCNs have a high or moderate probability of being found in this ecological landscape and use habitats that have the best chance for management here. Data are from the Wisconsin Wildlife Action Plan (WDNR 2005) and Appendix E, "Opportunities for Sustaining Natural Communities in Each Ecological Landscape," in Part 3, "Supporting Materials." For more complete and/or detailed information, please see the Wisconsin Wildlife Action Plan. The Wildlife Action Plan is meant to be dynamic and will be periodically updated to reflect new information; the next update is planned for 2015.

Only SGCNs highly or moderately (H = high association, M = moderate association) associated with specific community types or other habitat types and which have a high or moderate probability of occurring in the ecological landscape are included here (SGCNs with a low affinity with a community type or other habitat type and with low probability of being associated with this ecological landscape were excluded). Only community types designated as "Major" or "Important" management opportunities for the ecological landscape are shown.


Henslow's Sparrow.
Photo © Laurie Smaglick Johnson.

	MAJOR														IMPORTANT																	
	Calcareous Fen	Central Sands Pine - Oak Forest	Coastal Plain Marsh	Coldwater Streams	Emergent Marsh	Impoundments/Reservoirs	Inland Lakes	Northern Wet Forest	Shrub Carr	Southern Dry Forest	Southern Sedge Meadow	Submergent Marsh	Warmwater Rivers	Wet-mesic Prairie	Alder Thicket	Bedrock Glade	Bog Relict	Coolwater Streams	Dry Prairie	Floodplain Forest	Moist Cliff	Northern Hardwood Swamp	Northern Sedge Meadow	Oak Barrens	Open Bog	Pine Barrens	Sand Prairie	Southern Dry-mesic Forest	Southern Tamarack Swamp (rich)	Surrogate Grasslands	Warmwater Streams	Wet Prairie
Species That Are Significantly Associated with the Central Sand Hills Ecological Landscape																																
MAMMALS																																
Franklin's ground squirrel														M										H		H	H			M		
BIRDS[a]																																
Acadian Flycatcher																				M								H				
American Bittern					H						M												H		H							
American Woodcock	M								H						H		M					M							M			
Bald Eagle						H	H					M	H																			
Black Tern					H	M	M					M											M									
Black-billed Cuckoo									H						H					M				M		M			M			
Blue-winged Teal					H	M	M				M	M		M						M			M							M		M
Blue-winged Warbler									M	M						M	M			M								M	M			
Bobolink											M			H									H		M				H			H
Brown Thrasher																			M					H		H	H			M		
Cerulean Warbler																				H								H				
Dickcissel																														H		
Eastern Meadowlark											M			M					M								M			H		
Field Sparrow														M					H					M		M	H			M		
Forster's Tern					H	M						M																				
Grasshopper Sparrow																			H					M			H			H		
Henslow's Sparrow														M											M					H		M
Least Flycatcher																				M		M										
Northern Bobwhite														M					M											H		
Northern Harrier											M			H					M				H	M	M	M				H		M
Red-headed Woodpecker		M								M										M				M				M				
Red-shouldered Hawk																				H								M				
Short-billed Dowitcher					H	M																										
Veery								M	H						H					M		H						M				

Continued on next page

Appendix 9.E, *continued.*


Lake sturgeon.
Photo by Wisconsin DNR staff.

	MAJOR														IMPORTANT															
	Calcareous Fen	Central Sands Pine - Oak Forest	Coastal Plain Marsh	Coldwater Streams	Emergent Marsh	Impoundments/Reservoirs	Inland Lakes	Northern Wet Forest	Shrub Carr	Southern Dry Forest	Southern Sedge Meadow	Submergent Marsh	Warmwater Rivers	Wet-mesic Prairie	Alder Thicket	Bedrock Glade	Bog Relict	Coolwater Streams	Dry Prairie	Floodplain Forest	Moist Cliff	Northern Hardwood Swamp	Northern Sedge Meadow	Oak Barrens	Open Bog	Pine Barrens	Sand Prairie	Southern Dry-mesic Forest	Southern Tamarack Swamp (rich)	Surrogate Grasslands	Warmwater Streams	Wet Prairie
Vesper Sparrow																			H					H		H	H				
Western Meadowlark																			M					M			M			H	
Whip-poor-will		H								H						M	M							M		M		H			
Whooping Crane					H						M	H											M		M						
Willow Flycatcher	M								H		M			M			M												M		M
Wood Thrush										M										M								H			
Yellow-billed Cuckoo									M											H								M			
HERPTILES																															
Blanding's turtle			M	M	H	H	H		M		M	H	M	M	M			M	H	M			M	H		H	H	M	M		M	H
Midland smooth softshell turtle													H																		
Ornate box turtle		H								H									H								H	H			
Western slender glass lizard																			H					H		H	H				
FISH																															
Black buffalo						M							M																		
Lake sturgeon						H	H						H																		
Least darter							M						M																	M	
Paddlefish													M																		
Shoal chub (speckled chub)													H																		
Western sand darter													M																		
Species That Are Moderately Associated with the Central Sand Hills Ecological Landscape																															
MAMMALS																															
Eastern red bat	M	M	M	H	M		M	M	M	M	M	M	M		M		M	H		M		M	M	M	M			M			M	
Gray wolf		H						H	M	M					H					M		M		M	M	M		M				
Hoary bat	M	M	M	H	M		M	M	M		M	M	M		M		M	H		M		M	M		M						M	
Northern long-eared bat	M	M	M	H	M		M		M	M	M	M	M		M		M	H		M		M	M	M	M			M			M	
Prairie vole																			H					M			H			M		
Silver-haired bat	M	M	M	H	M		M	M	M		M	M	M		M		M	H		M		M	M		M						M	
Water shrew				H			M	H							M			H		M		H									M	
BIRDS																															
American Golden Plover					M	M								M															M			M
Dunlin					M	M							M																			
Golden-winged Warbler								M	H						H							M			M							
Hudsonian Godwit					H																											
Lark Sparrow																			M					H		M	H					
Le Conte's Sparrow														M									H		M					H		M
Osprey						H	H						H																			
Red Crossbill																										M						
Rusty Blackbird	M				M				M						M		M			H					M				M			
Short-eared Owl									M		M			H					M				M							H		M

Continued on next page

Appendix 9.E, *continued.*


Yellow Rail.
Photo by Julio Mulero.

	MAJOR														IMPORTANT															
	Calcareous Fen	Central Sands Pine - Oak Forest	Coastal Plain Marsh	Coldwater Streams	Emergent Marsh	Impoundments/Reservoirs	Inland Lakes	Northern Wet Forest	Shrub Carr	Southern Dry Forest	Southern Sedge Meadow	Submergent Marsh	Warmwater Rivers	Wet-mesic Prairie	Alder Thicket	Bedrock Glade	Bog Relict	Coolwater Streams	Dry Prairie	Floodplain Forest	Moist Cliff	Northern Hardwood Swamp	Northern Sedge Meadow	Oak Barrens	Open Bog	Pine Barrens	Sand Prairie	Southern Dry-mesic Forest	Southern Tamarack Swamp (rich)	Surrogate Grasslands	Warmwater Streams	Wet Prairie
Solitary Sandpiper			M	M	H													M		H					M						
Upland Sandpiper														M					H					M		M	M			H		M
Yellow Rail																							H		H							
HERPTILES																																
Gophersnake		M								M						H			H					H		H	H	M				
Four-toed salamander				M	H			M	H		M				H		H	M		H		M	M		H				M			
Pickerel frog	M			H	H	H	M	M	M		H	H	H	H	M			H		M			H		M						H	H
Yellow-bellied racer										M									H					M		M	H	M				
FISH																																
Banded killifish							M																									

[a]The common names of birds are capitalized in accordance with the checklist of the American Ornithologists Union.

Appendix 9.F. *Natural communities[a] for which there are management opportunities in the Central Sand Hills Ecological Landscape.*

Major opportunity[b]	Important opportunity[c]	Present[d]
Northern Wet Forest (Tamarack Swamp)	Northern Hardwood Swamp	Northern Dry Forest
		Northern Dry-Mesic Forest
	Southern Dry-Mesic Forest	Northern Mesic Forest
Southern Dry Forest	Floodplain Forest	Northern Wet-Mesic Forest
Central Sands Pine – Oak Forest		
	Pine Barrens	Southern Mesic Forest
Shrub-carr	Oak Barrens	
		Oak Opening
Wet-Mesic Prairie	Alder Thicket	Oak Woodland
Southern Sedge Meadow	Bog Relict	Cedar Glade
Calcareous Fen	Dry Prairie	Dry-Mesic Prairie
		Mesic Prairie
Emergent Marsh	Sand Prairie	
Submergent Marsh	Wet Prairie	Emergent Marsh – Wild Rice
Coastal Plain Marsh	Northern Sedge Meadow	Ephemeral Pond
Coldwater Stream	Surrogate Grasslands	
Impoundment/Reservoir		
Inland Lake	Open Bog	
Warmwater River		
	Bedrock Glade	
	Dry Cliff (Curtis' Exposed Cliff)	
	Moist Cliff (Curtis' Shaded Cliff)	
	Inland Beach	
	Coolwater Stream	
	Warmwater Stream	

[a]See Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin," for definitions of natural community types. Also see Appendix E, "Opportunities for Sustaining Natural Communities in Each Ecological Landscape," in Part 3 ("Supporting Materials") for an explanation on how the information in this table can be used.

[b]Major opportunity – Relatively abundant, represented by multiple significant occurrences, or ecological landscape is appropriate for major restoration activities.

[c]Important opportunity – Less abundant but represented by one to several significant occurrences or type is restricted to one or a few ecological landscapes.

[d]Present – Uncommon or rare, with no good occurrences documented. Better opportunities are known to exist in other ecological landscapes, or opportunities have not been adequately evaluated.

Appendix 9.G. *Public conservation lands in the Central Sand Hills Ecological Landscape, 2005.*

Property name	Size (acres)[a]
STATE	
Caves Creek State Fishery Area	810
Comstock Bog-Meadow State Natural Area	630
Devils Lake State Park[b]	460
Emmons Creek State Fishery Area[b]	1,120
French Creek State Wildlife Area	3,260
Germania State Wildlife Area	2,410
Glacial Habitat Restoration Area[b]	340
Grand River Marsh State Wildlife Area	6,990
Grassy Lake State Wildlife Area	690
Greenwood State Wildlife Area	1,440
Hartman Creek State Park[b]	390
Hinkson Creek State Fishery Area	230
Jennings Creek State Wildlife Area	530
John A. Lawton State Fishery Area	280
Lawrence Creek State Wildlife Area	940
Lodi Marsh State Wildlife Area	1,090
Lower Wisconsin State Riverway[b]	250
Mecan River State Fishery Area	6,390
Mud Lake State Wildlife Area - Columbia County[b]	2,010
Peter Helland State Wildlife Area	3,070
Pine Island State Wildlife Area	5,260
Pine River System State Fishery Area	1,920
Radley Creek State Fishery Area	1,420
Rocky Run Creek State Fishery Area	710
Rowan Creek State Fishery Area	650
Swan Lake State Wildlife Area	2,290
Upper Neenah State Fishery Area	380
White River State Fishery Area	2,970
White River Marsh State Wildlife Area[b]	840
Willow Creek State Fishery Area[b]	1,840
Miscellaneous Lands[c]	4,260
FEDERAL	
Fox River National Wildlife Refuge	800
Waterfowl Production Areas	3,050
COUNTY FOREST[d]	
None	
TOTAL	**59,720**

Source: *Wisconsin Land Legacy Report* (WDNR 2006b).

[a]Actual acres owned in this ecological landscape.

[b]This property also falls within adjacent ecological landscape(s).

[c]Includes public access sites, fish hatcheries, fire towers, streambank and nonpoint easements, lands acquired under statewide wildlife, fishery, forestry, and natural area programs, Board of Commissioners of Public Lands holdings, small properties under 100 acres, and properties with fewer than 100 acres within this ecological landscape.

[d]Locations and sizes of county-owned parcels enrolled in the Forest Crop Law program are presented here. Information on locations and sizes of other county and local parks in this ecological landscape is not readily available and is not included here, except for some very large properties.

Appendix 9.H. *Land Legacy places in the Central Sand Hills Ecological Landscape and their ecological and recreational significance.*

The *Wisconsin Land Legacy Report* (WDNR 2006b) identified 16 places in the Central Sand Hills Ecological Landscape that merit conservation action based upon a combination of ecological significance and recreational potential.

Map Code	Place name	Size	Protection initiated	Protection remaining	Conservation significance[a]	Recreation potential[b]
AP	Arlington Prairie	Small	Moderate	Moderate	x	xx
BA	Badger Army Ammunition Plant	Medium	Substantial	Limited	xxxx	xxxxx
BO	Baraboo River	Large	Limited	Moderate	xxxx	xxxxx
CM	Comstock – Germania Marshes	Small	Substantial	Limited	xxxx	x
GL	Grand River Marsh and Lake Puckaway	Medium	Substantial	Moderate	xxx	xxxx
HE	Hartman and Emmons Creeks	Small	Substantial	Limited	xxxx	xxx
LM	Lewiston Marsh	Medium	Limited	Moderate	xxx	x
LV	Little Plover River	Small	Moderate	Moderate	xx	xxx
MW	Middle Wisconsin River	Large	Limited	Moderate	xxxxx	xxxx
MP	Montello Area Coastal Plain Marshes	Small	Limited	Moderate	xxxxx	x
NN	Neenah Creek	Small	Moderate	Limited	xx	x
OX	Oxford Savanna	Medium	Limited	Substantial	xxxxx	xxx
PV	Plover River	Medium	Limited	Substantial	xxx	xxx
PB	Portage to Buffalo Lake Corridor	Medium	Limited	Moderate	xxx	xxxxx
SC	Sand Country Trout Streams	Large	Substantial	Moderate	xxxx	xxxx
WM	White River Marsh and Uplands	Large	Substantial	Limited	xxxx	xx

[a]**Conservation significance.** See the *Wisconsin Land Legacy Report* (WDNR 2006b), p. 43, for detailed discussion.

- xxxxx Possesses outstanding ecological qualities, is large enough to meet the needs of critical components, and/or harbors globally or continentally significant resources. Restoration, if needed, has a high likelihood of success.
- xxxx Possesses excellent ecological qualities, is large enough to meet the needs of most critical components, and/or harbors continentally or Great Lakes regionally significant resources. Restoration has a high likelihood of success.
- xxx Possesses very good ecological qualities, is large enough to meet the needs of some critical components, and/or harbors statewide significant resources. Restoration will typically be important and has a good likelihood of success.
- xx Possesses good ecological qualities, may be large enough to meet the needs of some critical components, and/or harbors statewide or ecological landscape significant resources. Restoration is likely needed and has a good chance of success.
- x Possesses good to average ecological qualities, may be large enough to meet the needs of some critical components, and/or harbors ecological landscape significant resources. Restoration is needed and has a reasonable chance of success.

[b]**Recreation potential.** See the Wisconsin Land Legacy Report, p. 43, for detailed discussion.

- xxxxx Outstanding recreation potential, could offer a wide variety of land and water-based recreation opportunities, could meet many current and future recreation needs, is large enough to accommodate incompatible activities, could link important recreation areas, and/or is close to state's largest population centers.
- xxxx Excellent recreation potential, could offer a wide variety of land and water-based recreation opportunities, could meet several current and future recreation needs, is large enough to accommodate some incompatible activities, could link important recreation areas, and/or is close to large population centers.
- xxx Very good recreation potential, could offer a variety of land and/or water-based recreation opportunities, could meet some current and future recreation needs, may be large enough to accommodate some incompatible activities, could link important recreation areas, and/or is close to mid-sized to large population centers.
- xx Good to moderate recreation potential, could offer some land and/or water-based recreation opportunities, might meet some current and future recreation needs, may not be large enough to accommodate some incompatible activities, could link important recreation areas, and/or is close to mid-sized population centers.
- x Limited recreation potential, could offer a few land and/or water-based recreation opportunities, might meet some current and future recreation needs, is not likely large enough to accommodate some incompatible activities, could link important recreation areas, and/or is close to small population centers.

Appendix 9.I. *Importance of economic sectors (based on the number of jobs) within the Central Sand Hills Counties compared to the rest of the state.*

Industry	CLMC	CSH	CSP	FT	NCF	NES	NH	NLMC	NWL	NWS	SEGP	SLMC	SWS	SCP	WCR	WP
Agriculture, Fishing & Hunting	0.87	2.14	2.41	2.15	2.15	1.90	0.50	2.71	0.43	1.29	0.76	0.10	4.46	0.87	2.36	2.30
Forest Products & Processing	1.64	0.98	1.83	2.40	3.43	2.20	1.33	1.74	0.41	1.07	0.65	0.32	0.45	1.44	0.96	0.69
Mining	1.08	1.64	0.79	0.79	2.69	3.55	0.91	2.16	0.16	0.34	1.47	0.19	0.62	0.08	0.77	1.21
Utilities	2.44	1.08	0.81	0.39	0.61	0.45	0.58	0.41	1.96	1.76	0.67	0.65	0.81	1.83	1.19	0.51
Construction	1.12	1.02	0.89	0.96	1.14	0.92	2.38	1.08	1.07	1.14	1.08	0.67	0.98	1.13	1.03	1.11
Manufacturing (non-wood)	1.23	1.02	0.74	0.98	0.90	1.37	0.21	1.15	0.49	0.59	1.19	0.87	0.78	0.46	0.77	0.99
Wholesale Trade	0.99	0.63	0.61	0.95	0.62	0.53	0.47	0.60	1.15	0.72	1.16	0.98	0.89	0.76	0.83	0.53
Retail Trade	1.01	1.00	0.99	1.11	1.11	1.00	1.66	1.03	1.30	1.19	1.02	0.80	1.69	1.11	1.11	1.13
Tourism-related	0.99	1.12	0.97	0.86	0.99	1.05	1.51	1.28	1.34	1.41	0.94	1.02	0.78	1.33	1.08	1.12
Transportation & Warehousing	0.95	1.32	2.13	1.40	1.19	1.15	0.80	0.89	3.25	2.15	0.82	0.83	0.74	2.12	1.39	0.99
Information	0.76	0.49	0.69	0.74	0.58	0.68	0.80	0.70	0.38	0.49	1.22	1.11	1.09	0.64	0.62	0.57
Finance & Insurance	1.22	1.31	0.89	0.96	0.56	0.46	0.43	0.48	0.47	0.46	1.04	1.18	0.65	0.45	0.70	0.55
Real Estate, Rental & Leasing	0.84	0.73	0.59	0.60	0.52	0.34	1.37	0.95	0.42	0.50	1.17	1.14	0.47	0.46	0.87	0.66
Pro, Science & Tech Services	0.85	0.53	0.46	0.55	0.41	0.36	0.43	0.45	0.51	0.47	1.04	1.51	0.49	0.47	0.63	0.81
Management	0.80	0.26	0.63	0.54	0.37	0.21	0.17	0.24	0.65	0.47	0.94	1.62	0.08	0.64	0.87	0.45
Admin, Support, Waste, & Remediation	0.99	0.42	0.43	0.46	0.34	0.23	0.61	0.34	0.61	0.43	0.92	1.64	0.58	0.51	0.70	0.63
Private Education	0.86	0.68	0.39	0.42	0.86	0.72	0.87	0.55	0.08	0.12	0.80	1.94	0.09	1.53	0.68	0.55
Health Care & Social Services	0.85	0.88	1.27	1.04	0.82	0.90	0.87	0.84	0.96	0.91	0.83	1.32	0.84	0.99	1.09	0.94
Other Services	1.08	1.32	1.10	1.05	1.10	1.13	1.25	1.19	1.36	1.09	1.06	0.84	1.14	1.13	0.91	1.29
Government	0.78	1.09	1.11	1.03	1.26	1.36	1.08	1.03	1.36	1.54	1.04	0.89	1.15	1.50	1.14	1.21

Source: Based on an economic base analysis using location quotients (Quintero 2007). Definitions of economic sectors can be found at the U.S. Census Bureau's North American Industry Classification System web page (USCB 2013).

Appendix 9.J. *Scientific names of species mentioned in the text.*

Common name	Scientific name
Acadian Flycatcher[a]	*Empidonax virescens*
American basswood	*Tilia americana*
American beaver	*Castor canandensis*
American Bittern	*Botaurus lentiginosus*
American Woodcock	*Scolopax minor*
Annosum root rot fungus	*Heterobasidion annosum*
Aspens	*Populus* spp.
Aspen heart rot fungus	*Phellinus tremulae*
Aspen hypoxylon canker fungus	*Hypoxylon mammatum*
Bald Eagle	*Haliaeetus leucocephalus*
Banded killifish	*Fundulus diaphanus*
Barn Owl	*Tyto alba*
Bell's Vireo	*Vireo bellii*
Black-billed Cuckoo	*Coccyzus erythropthalmus*
Black buffalo	*Ictiobus niger*
Black cherry	*Prunus serotina*
Black oak	*Quercus velutina*
Black spruce	*Picea mariana*
Black Tern	*Chlidonias niger*
Blanchard's cricket frog	*Acris blanchardi*
Blanding's turtle	*Emydoidea blandingii*
Bluegill	*Lepomis macrochirus*
Blue sucker	*Cycleptus elongatus*
Blue-gray Gnatcatcher	*Polioptila caerulea*
Blue-winged Teal	*Anas discors*
Blue-winged Warbler	*Vermivora cyanoptera,* listed as *Vermivora pinus* on the Wisconsin Natural Heritage Working List
Bobolink	*Dolichonyx oryzivorus*
Bog bluegrass	*Poa paludigena*
Box elder	*Acer negundo*
Brittle prickly pear	*Opuntia fragilis*
Brook grass	*Catabrosa aquatica*
Brook trout	*Salvelinus fontinalis*
Brown Thrasher	*Toxostoma rufum*
Brown trout	*Salmo trutta*
Buckhorn	*Tritogonia verrucosa*
Bullhead (sheepnose)	*Plethobasus cyphyus*
Bulrush	*Schoenoplectus and Scirpus* spp.
Bur oak	*Quercus macrocarpa*
Bur-reeds	*Sparganium* spp.
Bushy aster	*Aster dumosus*
Cerulean Warbler	*Setophaga cerulea,* listed as *Dendroica cerulea* on the Wisconsin Natural Heritage Working List
Channel catfish	*Ictalurus punctatus*
Chestnut-sided Warbler	*Setophaga pensylvanica*
Common buckthorn	*Rhamnus cathartica*
Common carp	*Cyprinus carpio*
Common reed	*Phragmites australis*
Curly-leaf pondweed	*Potamogeton crispus*
Cypress spurge	*Euphorbia cyparissias*
Diplodia pine blight fungus	*Diplodia pinea*
Downy willow-herb	*Epilobium strictum*
Dwarf umbrella-sedge	*Fuirena pumila*
Eastern hemlock	*Tsuga canadensis*
Eastern larch beetle	*Dendroctonus simplex*

Continued on next page

Appendix 9.J, *continued.*

Common name	Scientific name
Eastern massasauga	*Sistrurus catenatus catenatus*
Eastern Meadowlark	*Sturnella magna*
Eastern red bat	*Lasiurus borealis*
Eastern red damsel	*Amphiagrion saucium*
Eastern Towhee	*Pipilo erythrophthalmus*
Eastern Whip-poor-will	*Caprimulgus vociferus*
Eastern white pine	*Pinus strobus*
Eastern Wood-Pewee	*Contopus virens*
Elms	*Ulmus* spp.
Emerald ash borer	*Agrilus planipennis*
Eurasian honeysuckles	*Lonicera tatarica, L. morrowii, and L.* x *bella*
Eurasian water-milfoil	*Myriophyllum spicatum*
Fassett's locoweed	*Oxytropis campestris* var. *chartacea*
Field Sparrow	*Spizella pusilla*
Flodman's thistle	*Cirsium flodmanii*
Forest tent caterpillar	*Malacosoma disstria*
Forster's tern	*Sterna forsteri*
Franklin's ground squirrel	*Spermophilus (Poliocitellus) franklinii*
Garlic mustard	*Alliaria petiolata*
Gizzard shad	*Dorosoma cepedianum*
Glossy buckthorn	*Rhamnus frangula*
Gophersnake	*Pituophis catenifer*
Golden-winged Warbler	*Vermivora chrysoptera*
Goldeye	*Hiodon alosoides*
Gorgone checkerspot	*Chlosyne gorgone*
Grasshopper Sparrow	*Ammodramus savannarum*
Gray wolf	*Canis lupus*
Greater Prairie-Chicken	*Tympanuchus cupido*
Greater redhorse	*Moxostoma valenciennesi*
Green ash	*Fraxinus pennsylvanica*
Gypsy moth	*Lymantria dispar*
Hard-stem bulrush	*Schoenoplectus acutus*
Henslow's Sparrow	*Ammodramus henslowii*
Hickories	*Carya* spp.
Hill's thistle	*Cirsium hillii*
Jack pine	*Pinus banksiana*
Jack pine budworm	*Choristoneura pinus*
Karner blue butterfly	*Lycaeides melissa samuelis*
Lake chubsucker	*Erimyzon sucetta*
Lake sturgeon	*Acipenser fulvescens*
Larch casebearer	*Coleophora laricella*
Larch sawfly	*Pristiphora erichsonii*
Largemouth bass	*Micropterus salmoides*
Lark Sparrow	*Chondestes grammacus*
Le Conte's Sparrow	*Ammodramus leconteii*
Leafy spurge	*Euphorbia esula*
Least darter	*Etheostoma microperca*
Leonard's skipper	*Hesperia leonardus*
Loggerhead Shrike	*Lanius ludovicianus*
Long-beaked bald-rush	*Psilocarya scirpoides*
Longear sunfish	*Lepomis megalotis*
Lotus	*Nelumbo lutea*
Maples	*Acer* spp.
Meadow beauty	*Rhexia virginica*
Midland smooth softshell turtle	*Apalone muticus*

Continued on next page

Appendix 9.J, *continued.*

Common name	Scientific name
Monkeyface	*Quadrula metanevra*
Mud darter	*Etheostoma spectabile*
Muskelunge	*Esox masquinongy*
North American river otter	*Lontra canadensis*
Northern cricket frog	*Acris crepitans*
Northern Flicker	*Colaptes auratus*
Northern Harrier	*Circus cyaneus*
Northern long-eared bat	*Myotis septentrionalis*
Northern pike	*Esox lucius*
Northern pin oak	*Quercus ellipsoidalis*
Northern red oak	*Quercus rubra*
Northern white-cedar	*Thuja occidentalis*
Oak wilt fungus	*Ceratocystis fagacearum*
Ornate box turtle	*Terrapene ornata*
Osprey	*Pandion haliaetus*
Ovenbird	*Seiurus aurocapilla*
Passenger Pigeon	*Ectopistes migratorius*
Pickerel frog	*Lithobates palustris*
Pileated Woodpecker	*Dryocopus pileatus*
Pine sawfly	*Neodiprion* spp.*, Diprion* spp.
Pirate perch	*Aphredoderus sayanus*
Prairie bush-clover	*Lespedeza leptostachya*
Prairie fame-flower	*Talinum rugospermum*
Prairie leafhopper	*Polyamia dilata*
Prothonotary Warbler	*Protonotaria citrea*
Pugnose shiner	*Notropis anogenus*
Purple loosestrife	*Lythrum salicaria*
Red maple	*Acer rubrum*
Red pine	*Pinus resinosa*
Redfin shiner	*Lythrurus umbratilis*
Red-headed Woodpecker	*Melanerpes erythrocephalus*
Red-necked Grebe	*Podiceps grisegena*
Red pine pocket mortality fungi	*Leptographium terrebrantis* and *L. procerum*
Red-shouldered Hawk	*Buteo lineatus*
Red-tailed prairie leafhopper	*Aflexia rubranura*
Reed canary grass	*Phalaris arundinacea*
Regal fritillary	*Speyeria idalia*
Ringed boghaunter	*Williamsonia lintneri*
River birch	*Betula nigra*
River bluet	*Enallagma anna*
River redhorse	*Moxostoma carinatum*
Rock pocketbook	*Arcidens confragosus*
Ruffed Grouse	*Bonasa umbellus*
Rusty Blackbird	*Euphagus carolinus*
Rusty crayfish	*Orconectes rusticus*
Salamander mussel	*Simpsonaias ambigua*
Sand snaketail	*Ophiogomphus smithi*
Sandhill Crane	*Grus canadensis*
Scarlet Tanager	*Piranga olivacea*
Shadowy goldenrod	*Solidago sciaphila*
Shagbark hickory	*Carya ovata*
Sharp-tailed Grouse	*Tympanuchus phasianellus*
Shoal chub	*Macrhybopsis aestivalis*
Short-eared Owl	*Asio flammeus*
Silphium borer moth	*Papaipema silphii*

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Appendix 9.J, *continued.*

Common name	Scientific name
Silver maple	*Acer saccharinum*
Slender bulrush	*Schoenoplectus heterochaetus,* listed as *Scirpus heterochaetus* on the Wisconsin Natural Heritage Working List
Slim-stem small reed-grass	*Calamagrostis stricta*
Smallmouth bass	*Micropterus dolomieu*
Small white lady's-slipper	*Cypripedium candidum*
Spatterdock darner	*Rhionaeschna mutata*
Spotted knapweed	*Centaurea biebersteinii*
Sugar maple	*Acer saccharum*
Swamp metalmark	*Calephelis muticum*
Swamp thistle	*Cirsium muticum*
Tamarack	*Larix laricina*
Timber rattlesnake	*Crotalus horridus*
Twig-rush	*Cladium mariscoides*
Two-lined chestnut borer	*Agrilus bilineatus*
Upland Sandpiper	*Bartramia longicauda*
Vesper Sparrow	*Pooecetes gramineus*
Wallace's deepwater mayfly	*Spinadis simplex*
Walleye	*Sander vitreus*
Warpaint emerald	*Somatochlora incurvata*
Water-cress	*Nasturtium officinale*
Weed shiner	*Notropis texanus*
Western Meadowlark	*Sturnella neglecta*
Western ribbonsnake	*Thamnophis proximus*
Western sand darter	*Etheostoma clarum*
Western slender glass lizard	*Ophisaurus attenuatius*
White ash	*Fraxinus americana*
White birch	*Betula papyrifera*
White oak	*Quercus alba*
White pine blister rust	*Cronartium ribicola*
White-tailed deer	*Odocoileus virginianus*
Whooping Crane	*Grus americana*
Wild rice	*Zizania* spp.
Wild Turkey	*Meleagris gallopavo*
Willow Flycatcher	*Empidonax traillii*
Winged mapleleaf	*Quadrula fragosa*
Wood Thrush	*Hylocichla mustelina*
Wood turtle	*Glyptemys insculpta*
Woolly sedge	Carex lasiocarpa
Yellow-crowned Night-Heron	*Nyctanassa violacea*
Yellow perch	*Perca flavescens*
Yellow Rail	*Coturnicops noveboracensis*
Yellow-throated Vireo	*Vireo flavifrons*
Yellow wild-indigo	*Baptisia tinctoria*
Zebra mussel	*Dreissena polymorpha*

[a]The common names of birds are capitalized in accordance with the checklist of the American Ornithologists Union.

Appendix 9.K. *Maps of important physical, ecological, and aquatic features within the Central Sand Hills Ecological Landscape.*

- Vegetation of the Central Sand Hills Ecological Landscape in the Mid-1800s
- Land Cover of the Central Sand Hills Ecological Landscape in the Mid-1800s
- Landtype Associations of the Central Sand Hills Ecological Landscape
- Public Land Ownership, Easements, and Private Land Enrolled in the Forest Tax Programs in the Central Sand Hills Ecological Landscape
- Ecologically Significant Places of the Central Sand Hills Ecological Landscape
- Exceptional and Outstanding Resource Waters and 303(d) Degraded Waters of the Central Sand Hills Ecological Landscape
- Dams of the Central Sand Hills Ecological Landscape
- WISCLAND Land Cover (1992) of the Central Sand Hills Ecological Landscape
- Soil Regions of the Central Sand Hills Ecological Landscape
- Relative Tree Density of the Central Sand Hills Ecological Landscape in the Mid-1800s
- Population Density, Cities, and Transportation of the Central Sand Hills Ecological Landscape

Note: *Go to http://dnr.wi.gov/topic/landscapes/index.asp?mode=detail&Landscape=6 and click the "maps" tab.*

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